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(December, 1939)

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ORIGINAL ARTICLES

FURTHER STUDIES ON THE INHERITANCE OF LEAF SHAPE IN ASIATIC *GOSSYPIUMS*

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AND

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(Received for publication on 28th March 1939)

(With one text-figure)

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INTRODUCTION

IN a previous paper by the senior author [Hutchinson, 1934] on the inheritance of leaf shape in Asiatic cottons, a theory of the organization of the gene was put forward to account for the relationships between members of the leaf shape multiple allelomorph series. According to the theory, L^L (laciniated) carries four episomes on a single protosome, and L (narrow) carries one only. Intermediate allelomorphs carrying two or three episomes should be possible, and a search was made for them in the extensive collection of Indian types of *G. arboreum* var. *neglectum* (classification according to Hutchinson and Ghose [1937]) maintained at Indore. A new allelomorph was found in a strain known as 1090 obtained from Nagpur, Central Provinces. It will be given the symbol L^N .

DATA

1090 is a narrow-leaved type of *G. arboreum* var. *neglectum*. It has a deeper cut sinus, giving a higher index A than types carrying the L allelomorph, but about the same lobe width (and index B). (For definitions of the leaf indices used, see Hutchinson [1934]). 1090 resembles Burma laciniated and differs from strains carrying L in having no accessory lobes in the

sinuses between the main lobes (Fig. 1). Below are given leaf indices (at Indore) of typical strains carrying L^L , L and l for comparison with 1090.

Strain	Index A	Index B	Allelomorph
Burma laciniated	11.1	6.6	L^L
1090	6.8	3.8	L
Cawnpore White	3.5	4.0	L
Kokati narrow	3.3	3.9	L
1304	2.2	2.4	l
Kokati broad	2.2	2.5	l
Malvi 9	2.1	2.3	l

An outline of a 1090 leaf is given in Fig. 1.

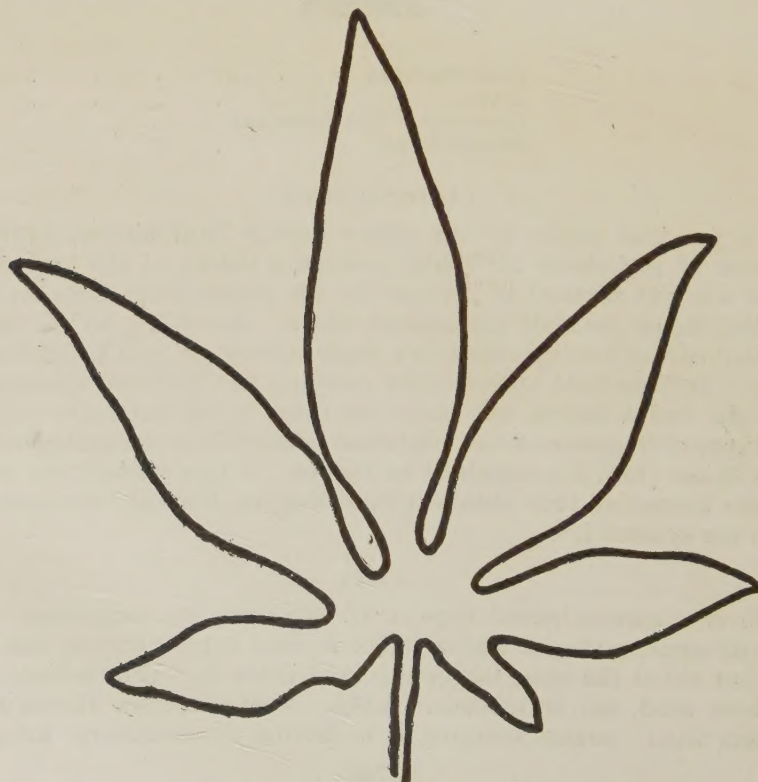


FIG. 1. Outline of a 1090 leaf

1090 was crossed with Cawnpore White and 1304, two of the strains used in Hutchinson's [1934] earlier investigation on leaf shape, and also with narrow and broad-leaved strains isolated from a brown-linted form of *G. arboreum* var. *neglectum* known as 'Kokati'. Small F_1 families were grown and the ranges in leaf index are given below.

F_1	Index A	Index B
1090 $\times$ C. W.	3.9-5.8	3.7-4.3
1090 $\times$ Kokati narrow	4.1-6.5	3.3-4.6
1090 $\times$ 1304	3.6-5.2	2.8-3.2
1090 $\times$ Kokati broad	4.5-5.2	3.1-3.4

In the F_1 accessory lobes occurred only rarely.

F_2 's and back-crosses to either Cawnpore White or Malvi 9 were grown. Correlation tables of index A and index B are given in Tables I-IV for F_2 's and VI-IX for back-crosses. The 1090 $\times$ C. W. and 1090 $\times$ 1304 F_2 's and back-crosses were grown in 1935-36, and plants were classed as either with or without accessory lobes, those having occasional accessory lobes, as in the F_1 , being classed as without. The Kokati crosses were grown in 1936-37, and were divided into three classes, with accessory lobes, without, and with occasional accessory lobes. In the tables, totals are given for accessory lobes present (+), absent (0), and occasional (?) for both index A and index B. The leaf index of narrow leaves (L , L^N and L^L) varies considerably with the season and the stage of development at which measurements are made. There are consequently considerable differences in the mean indices of L^N and L classes in different years and to some extent between families grown in the same year. Accurate comparisons of indices are therefore only possible between classes in the same family, unless the material has been grown under specially controlled conditions.

In F_2 's and back-crosses of crosses with L strains (Cawnpore White and Kokati narrow) the correlation between index A and index B was much lower than in $L \times L^L$ crosses (+0.40 and +0.17 against +0.86). Segregation was much more pronounced for index A than for index B, and plants with accessory lobes had a low index A, while those without, or with only occasional accessory lobes had a high index A. Overlapping occurred as would be expected, but the difference in index A between plants with accessory lobes and those with few or none is large and clear. In index B, as would be expected from the similarity of the parents, there was little evidence of segregation, and only a small difference between the accessory lobe classes. Segregation in index A was not sharp enough to allow of the separation of the two classes but it seemed probable that a close approach to the correct

classification would be obtained by taking the 'no accessory lobes' *plus* 'doubtful' as representing the 1090 and heterozygote classes, and the 'accessory lobes present' as the **L** class. Summaries are given below.

Cross	Accessory lobes			Total
	Present	Doubtful	Absent	
1090 × C. W.—F ₂	33	..	97	130
(1090 × C. W.) C. W. . . .	8	..	9	17
1090 × Kokati narrow—F ₂	106	66	268	440
(1090 × Kokati narrow) M9	29	11	20	60

The ratios obtained agree closely with the expected 3 : 1 and 1 : 1.

The Kokati parent carried the lint colour gene linked with the leaf shape multiple allelomorph series. If 1090 carries an allele in the **L** series, in F₂ the 1090 leaf class should be predominantly white linted, and the Kokati leaf class predominantly brown linted. Frequency arrays of index A for brown and white linted classes separately in F₂ and back-cross to M9 are given at the bottom of Tables II and VII. It will be seen that the white-linted class had a higher index A on the average than the brown-linted class, showing that the segregation in index A was due to a member of the **L** series linked with lint colour.

F₃ progenies were grown from 58 F₂ plants of 1090 × C.W., and were classified by eye into narrow like 1090 and narrow like C. W., and for presence or absence of accessory lobes. Frequency arrays of index A and index B of parents of F₃ progenies are given in Table I. F₃ progenies were of three kinds, homozygous high index A, no accessory lobes (12 progenies), segregating for index A and accessory lobes (33 progenies), and homozygous low index A with accessory lobes (13 progenies). The proportions are close to the expected 1 : 2 : 1 ratio. The F₃ progenies were classified by eye, and though a satisfactory approach to a 3 : 1 ratio was realized in segregating progenies, it cannot be regarded as being very accurate, and details are therefore omitted. Of the parents of F₃'s, all which gave homozygous high index A had a mean index A of 6.98 and no accessory lobes. Heterozygous F₂ plants had a mean index A of 5.25. Out of 33 plants, 29 had no accessory lobes, and 4, with index A at 3.3, 3.9, 4.2 and 4.3 had accessory lobes. Of the plants which gave homozygous **L** progenies, one had an index A of 8.0 and no accessory lobes. It is difficult to account for this unless there was some error in labelling. The other 12 had a mean index A of 3.56. Nine of them had accessory lobes and three, with index A at 3.7, 4.5 and 4.6, had none. Mean index B was 4.0 for all three classes. In index A the heterozygote was almost exactly half way between the homozygotes, showing no dominance. The development of accessory lobes is shown to be a fairly accurate test of the genotype, classification into **L^NL^N** + **L^NL** *v.* **LL** being correct in 88 per cent of cases. In any case the F₃ behaviour demonstrates single-factor inheritance conclusively.

In F_2 's and back-crosses of crosses with 1 strains, index A and index B were positively correlated, and taking the two together, a satisfactory distinction can be made between the 1090 plus heterozygote class, and the 1 class. The plants were classified for accessory lobes and the $L^N L^N$ and $L^N 1$ classes had none or only a few doubtful cases. In the 11 class about half the plants had them. Segregation was sharper in index A than index B, however, as would be expected, since the difference between the parents was much greater in index A than in index B. Segregation for lint colour occurred in the Kokati cross. The leaf shape and lint colour segregation are summarized below :—

Cross	Broad	L1	Narrow and intermediate	Total
1090 $\times$ 1304— F_2	39	..	114	152
(1090 $\times$ 1304) C. W.	..	17	22	39
1090 $\times$ Kokati broad— F_2 —				
Brown	52	..	132	} 255
White	4	..	67	
(1090 $\times$ Kokati broad) M9	14	..	23	37

Three of the plants measured for leaf shape produced no lint, so the lint colour—leaf shape totals do not exactly match the leaf shape tables. Crossing over per cent = 24.8 in F_2 . The leaf-shape ratios closely approach the expected 3 : 1 and 1 : 1 and the crossover percentage is not far from Hutchinson's [1934] estimates in crosses involving the lint colour—leaf shape linkage. 1090, therefore, carries an allelomorph of the L series.

F_3 's were grown from 37 F_2 plants of 1090 $\times$ 1304. Apart from one abnormal progeny (discussed below), they were of three kinds, 13 progenies from plants with index A from 4.4 to 8.6 and index B from 3.0 to 4.6 which gave 1090 type (L^N) only, 13 progenies from plants with index A from 3.4 to 8.4 and index B from 3.0 to 4.0 which segregated into approximately 3, 1090 type : 1 broad, and 10 progenies from plants with index A from 2.0 to 3.0 and index B from 2.2 to 3.0 which gave broads (1) only. The defect of heterozygotes from the expected 1 : 2 : 1 is satisfactorily accounted for by the fact that a larger proportion of plants with high and low indices than with intermediate indices was selected as parents of F_3 .

One F_2 plant with index A 5.8 and index B 4.2 behaved abnormally in F_3 . Instead of giving 1090 types and broads only, it gave 11 like 1090 : 5 narrow. Four of those like 1090 were grown to F_4 . Two bred true and two segregated, giving 12 like 1090 : 14 narrow. Of four narrows, two gave narrows only and two gave 26 like 1090 : 19 narrow. The labelling was carefully checked, and there was no evidence of error.

It is recorded here as it seems likely that an L gene appeared by mutation in homozygous L^N .

1090 was crossed with the Burma laciniated type B L. The F_1 was intermediate. Leaf measurements were taken and lint colour recorded on an F_2 of 400 plants. A correlation table of index A and index B is given in Table V. The two indices were highly correlated. The 1090 type segregates were distinguishable with confidence in the field by their broader lobes and shallower sinuses. The field classification agreed well with the measurements. Inspection of Table V will show that a group of plants with comparatively low indices (modes 5.0 index A and 3.6 index B) is separated from the rest by an area of low frequency. Dividing at the line passing through the area of low frequency gives 302 laciniated : 98 narrow, or very close to 3 : 1. This division agrees well with the eye classification, only six plants judged to be laciniated falling in the narrow class by measurement (marked with* in Table V). The Burma laciniated parent was brown linted, so the linkage between brown-lint and leaf shape should result in a preponderance of brown-linted laciniated, and white-linted narrow plants. There were 247 $L^L K$: 55 $L^L k$: 61 LNK : 37 LNk giving 36.5 per cent crossing over, and confirming the allelomorphism of L^L and LN .

DISCUSSION AND SUMMARY

It is clear from the leaf shape of the new allelomorph that no such simple scheme as that proposed by Hutchinson [1934] will fit the facts. The original hypothesis was successful in predicting the existence of other allelomorphs, but the one found fails to fit into the series. Detailed discussion of the relationships between the allelomorphs can only be made when they have been transferred to a common genetic background and measured under strictly comparable conditions. Some preliminary conclusions can be drawn from a comparison of the leaf indices of the parental types given below :

	Index A	Index B	Allelomorph
Burma laciniated	11.1	6.6	L^L
1090	6.8	3.8	LN
Kokati narrow	3.3	3.9	L
Kokati broad	2.2	2.5	1

Index A and index B do not run parallel, LN having a much higher index A and about the same index B as L types. This is borne out by the absence of segregation in index B in $LN \times L$ crosses. The hypothesis can be modified to embrace the new facts by supposing that sinus length and lobe width are controlled by independent portions of the gene.

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Hutchinson, J. B. and Ghose, R. L. M. (1937). *Ind. J. Agric. Sci.* **7**, 233

Correlation between index A and index

[illegible]

B in 1090 × *C. W.*—*F*₂

																	Totals		Parents of <i>F</i> ₂ progenies		
																	+	0	like 1090	het.	L
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...
	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...
..	1	1	...	...	...	...	1	...	...	...	...	...	...	...	1	...	1	4	...	3	1
..	1	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	1	5	1	1	1
..	1	...	...	1	...	...	...	...	...	1	...	...	...	...	...	...	2	7	1	1	...
..	1	...	...	...	...	...	...	...	1	...	...	...	...	...	1	...	1	8	1	4	...
3	...	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	3	12	2	3	3
..	...	...	2	...	...	...	1	...	...	...	...	...	...	...	...	...	8	20	1	8	3
..	2	...	...	1	...	1	...	...	...	2	...	...	...	...	...	...	10	18	4	7	3
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	13	1	3	2
..	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	3	8	1	3	...
..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	33	...	...	...	...
5	7	3	3	2	1	1	2	1	1	3	...	1	...	...	2	...	97	...	...	...	...
1	1	...	...	...	1	...	1	...	...	2	...	1	...	...	...	...	...	12	...	...	...
1	2	2	1	...	...	...	1	...	...	...	...	...	...	...	...	...	4	29	...	...	...
..	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	10	3	...	...	...

TABLE II

Correlation between index A and index B

		Index A													
		2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6
Index B	4.8	...	...	...	...	...	...	1	1	...	...	...	...	...	...
	4.6	...	...	...	...	...	1	1	1	1	1	...	1	2	...
	4.4	...	...	...	...	...	2	3	1	2	...	1	...	2	5
	4.2	...	...	...	...	4	2	3	1	3	4	3	4	8	6
	4.0	...	...	...	1	8	6	7	4	5	3	7	11	11	3
	3.8	...	...	...	2	6	4	4	4	7	9	12	17	10	10
	3.6	...	...	1	9	3	5	3	6	6	9	12	6	8	3
	3.4	...	...	1	6	2	4	1	7	2	4	3	2	2	5
	3.2	...	...	3	...	2	...	3	2	...	1	1	1	1	1
	3.0	1	...	1	...	1	1	...	1	...	...	...	...	...	...
Totals	+	1	...	6	15	24	18	19	11	3	4	3	...	...	1
	?	...	...	...	...	...	...	3	6	9	7	13	10	8	3
	0	...	...	...	3	2	7	4	11	14	20	23	32	36	29
	Brown	1	...	5	18	22	17	20	24	23	27	31	31	32	24
	White	...	...	1	...	4	8	6	4	3	4	8	11	12	9

n 1090 × *Kokati narrow*— F_2

												Total		
8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	+	?	0
.	...	...	...	...	...	...	...	...	...	...	...	2	...	...
.	1	...	...	...	...	...	...	...	...	...	...	5	2	2
}	2	...	1	1	...	...	...	...	...	...	1	6	2	16
}	4	...	2	1	...	1	1	...	...	...	...	9	12	31
}	3	2	1	2	1	2	1	...	...	1	...	27	11	44
}	9	4	4	1	3	2	1	...	...	...	...	16	20	78
}	3	4	3	1	...	...	2	...	...	...	...	19	14	55
.	...	...	...	1	...	...	...	...	...	...	...	13	3	27
2	2	...	1	1	...	...	...	...	...	...	...	5	2	14
.	...	...	...	...	...	...	...	...	...	...	...	4	...	1
.	...	...	...	1	...	...	...	...	...	...	...	106	...	...
}	2	1	...	...	...	...	1	...	...	...	...	...	66	...
}	22	9	12	7	4	5	4	...	...	1	1	...	...	268
.	14	4	7	4	4	1	1	...	...	...	1	328	Brown	
}	10	6	5	4	...	4	4	...	...	1	...	112	White	

[illegible]

B in 1090 × 1304—F₂

																	Totals		Parents of F ₂ Progenies		
																	{		{		
																	+	0	like 1090		
																			het.	1	
.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0					
..	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	..	1	1	...	..
..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2	...	...	...
1	1	...	1	...	2	...	...	...	...	...	...	...	...	1	...	...	...	7	3	2	...
..	...	1	...	1	...	3	...	1	...	...	...	...	...	1	...	...	...	9	1	...	...
1	1	...	1	...	1	1	...	1	...	...	...	...	...	...	...	...	...	15	4	2	..
..	1	...	...	...	1	...	1	...	...	...	...	1	...	1	...	...	...	15	3	4	..
...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	22	...	3	..
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	23	1	2	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	18	...	...	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	9	...	..	3
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8	9	...	..	4
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	22	...	...	...	...
3	3	1	2	2	4	5	1	3	...	...	...	1	...	3	...	1	...	131	...	...	...
1	...	...	2	...	...	1	...	2	...	...	...	1	...	1	...	...	...	...	13	...	...
1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	13	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10

TABLE IV
Correlation between index A and index B i

		Index A															
		1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8
Index B	.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	4.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	3.8	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	1
	3.6	...	...	...	...	...	...	...	...	...	...	...	1	3	...	3	3
	3.4	...	...	...	...	1	..	...	2	2	2	3	6	4	6	3	4
	3.2	...	1	1	1	...	1	1	2	2	2	10	11	7	7	...	2
	3.0	...	...	...	1	...	1	2	1	8	6	8	4	3	3	5	1
	2.8	...	2	4	1	3	1	3	1	2	6	2	...	...	...	...	...
	2.6	2	4	8	6	...	...	1	1	...	...	...	1	...	...	...	...
	2.4	7	5	4	...	1	..	1	1	...	...	...	...	...	...	...	...
	2.2	1	2	1	2	..	..	...	...	..	...	...	...	...	...	...	...
	2.0	1	...	...	..	..	..	..	..	..	...	...	...	...	...	...	...
Totals	+	7	4	15	6	2	..	1	..	...	...	...	...	...	...	...	...
	?	...	...	...	...	...	...	...	...	...	1	1	...	...	4	...	...
	0	4	10	3	5	3	3	7	9	14	15	22	24	17	12	11	11

n 1090 × *Kokati broad*—*F*₂

												Totals		
5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	+	?	0
...	...	...	...	...	...	...	1	...	...	...	...	...	...	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	2	3	...	3	1	1	1	...	...	...	...	...	11
2	1	...	...	2	1	1	1	...	1	...	2	...	...	14
2	2	1	4	1	...	...	...	1	1	...	...	...	1	21
3	1	2	1	...	...	...	...	...	1	...	...	...	2	39
...	1	...	...	...	...	1	...	...	1	...	...	...	2	49
1	...	...	...	...	...	...	...	...	...	...	...	...	1	43
...	...	...	...	...	...	...	...	...	...	...	...	7	1	17
...	...	...	...	...	...	...	...	...	...	...	...	16	...	7
...	...	...	...	...	...	...	...	...	...	...	...	12	...	7
...	...	...	...	...	...	...	...	...	...	...	...	...	...	6
...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
...	...	...	...	...	...	...	...	...	...	...	...	35	...	...
...	...	...	1	...	...	...	...	...	...	...	...	...	7	...
8	5	5	7	3	4	3	3	2	4	...	2	...	..	216

TABLE V
Correlation table of index A and index

Index

3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0 5.2 5.4 5.6 5.8 6.0 6.2 6.4 6.6 6.8 7.0 7.2 7.4 7.6 7.8 8.0 8.2 8.4 8.6 8.8

Index B

8.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
7.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
7.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
6.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
6.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...
6.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	3	...	1
6.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2	2	...
6.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...	...	1	...	1	1	...
5.8	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	1	...	...	1	1	2	...	2	...
5.6	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1	...	...	1	...	...	1	2	...	1	...	1	...
5.4	...	...	...	...	...	...	...	...	...	...	...	1	...	1	1	...	1	4	...	5	2	...	...	3	2	2	...
5.2	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	1	...	2	2	1	1	1	3	1	1	1	...
5.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	1	3	2	...	1	...	...	...
4.8	...	...	...	...	...	...	...	1	...	1*	...	...	...	...	...	2	2	...	1	2	...	...	...	1	...	1	...
4.6	...	...	...	...	...	...	1	...	...	...	...	...	...	1*	...	1	1	...	...	...	...	...	...	...	...	...	...
4.4	...	...	...	...	...	1	...	2*	1	...	...	1*	...	1	1*	1	...	...	...	...	...	...	...	...	...	...	...
4.2	...	...	...	...	...	...	2	1	...	...	2	5*	3	...	1	...	...	...	2	...	...	1	...	...	...	...	...
4.0	...	...	...	...	1	...	3	5	...	2	4	1	1	...	2	1	...	...	...	...	...	...	...	...	...	...	...
3.8	...	...	...	2	1	4	5	2	1	3	4	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
3.6	1	...	...	2	...	1	...	2	...	...	1	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...
3.4	...	...	3	...	1	1	...	3	...	...	1	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
3.2	...	...	1	2	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

L ^N K	...	...	2	1	1	2	5	8	9	1	2	7	9	2	2	5	3	2	...	...	...	...	...	...	...	...	...
L ^N k	1	...	2	3	2	2	2	3	7	1	4	5	2	2	...	1	...	...	...	...	...	...	...	...	...	...	...
L ^L K	...	...	...	...	...	...	...	...	...	...	...	...	3	1	1	3	6	6	7	10	3	7	4	9	10	11	
L ^L k	...	...	...	...	...	...	...	...	...	...	...	1	...	1	2	...	...	3	...	4	4	...	2	2	...	2	

INHERITANCE OF LEAF SHAPE IN ASIATIC *GOSSYPIMUMS*

in 1090 × B. L.—F₂

	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	above 13.0	L ^N K	L ^N k	L ^L K	L ^L k
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...
...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
...	...	...	...	...	...	...	2	1	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	5	...
...	...	...	1	...	...	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...
...	...	...	...	...	...	...	...	...	1	1	...	...	...	1	2	...	...	1	...	...	4	...	...	9	1
...	...	...	...	...	...	1	...	...	...	...	1	2	1	...	...	...	...	...	...	...	2	...	...	7	1
...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	2	...	...	5	...
...	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	...	4	...	...	7	1
...	1	3	1	1	1	1	...	1	1	1	1	...	...	...	...	...	...	1	...	...	1	...	...	15	...
1	1	1	...	...	...	1	3	1	...	...	1	...	...	...	2	...	...	...	...	...	1	...	...	13	2
...	3	3	...	...	2	1	1	...	...	1	...	1	...	1	...	1	...	2	...	...	2	...	...	21	4
1	...	1	2	...	2	4	2	2	2	2	...	...	...	...	...	...	...	...	...	...	5	...	...	27	3
3	1	1	1	1	2	1	...	1	1	1	...	...	1	1	1	...	...	...	...	...	...	...	...	20	3
2	4	4	1	1	1	4	...	1	...	3	1	...	...	...	...	...	...	...	...	...	2	...	...	24	12
3	2	1	...	2	2	1	...	3	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	10	1
3	1	...	1	...	...	...	2	...	...	1	...	...	...	...	...	...	1	...	...	...	...	...	...	25	8
3	1	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	1	...	...	22	3
1	...	...	...	...	2	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	11	4
...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	8	2
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	2	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7	1	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	3	2	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15	5	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16	9	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	6	...	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	7	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	4	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	61	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	37	...	...
14	14	12	6	5	9	14	9	9	5	10	3	5	1	4	6	...	1	5	...	1	25	...	...	247	...
3	2	2	1	1	4	3	3	2	1	...	1	...	1	...	...	1	...	1	...	...	3	...	...	...	55

TABLE VI
Correlation between index A and index B in (1090 × C. W.) C. W.

Index B	Index A																Totals		
	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	+	0
4.2	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	1	...	1	2
4.0	...	...	...	...	...	4	...	...	...	...	...	...	1	...	...	1	1	4	3
3.8	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1	...	1	1
3.6	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
3.4	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1
3.2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
3.0	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1
2.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2.4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
+	...	...	2	...	...	6	...	...	...	...	...	...	...	...	...	...	...	8	...
Totals	0	1	...	...	...	...	...	1	1	...	...	...	1	...	1	3	1	...	9

TABLE VII
Correlation between index A and index B in (1090 $\times$ Kokati narrow) M9

Index B	Index A																Totals		
	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	+	?	0	
5.0	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1	...	...	
4.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
4.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
4.4	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	
4.2	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	
4.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
3.8	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	
3.6	...	...	1	2	3	1	2	...	1	1	...	3	...	1	1	1	...	3	
3.4	...	...	1	3	1	1	...	...	...	2	3	3	...	1	3	7	5	6	
3.2	...	3	2	...	2	...	...	...	...	3	...	...	...	...	1	6	1	8	
3.0	...	...	1	...	...	1	...	...	...	...	1	...	...	...	...	2	1	...	
2.8	...	...	3	...	1	...	...	...	...	...	...	...	...	...	...	3	...	1	
2.6	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	
2.4	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	
+	1	3	8	7	4	4	2	...	...	...	...	...	...	...	...	29	...	...	
?	...	...	...	...	2	...	1	...	...	2	2	1	...	...	3	...	11	...	
0	...	...	...	...	1	...	...	...	1	4	2	6	1	3	2	...	...	20	
Brown	1	2	6	3	1	3	2	...	...	2	1	...	...	...	1	22	Brown		
White	...	1	2	4	6	1	1	...	1	4	3	7	1	3	4	38	White		
Totals																			

Totals

TABLE VIII
Correlation between index A and index B in (1090 × 1304) C. W.

	Index A																Totals						
	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	+	0	
Index B	4.2	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...
	4.0	...	...	...	...	...	...	...	...	...	1	...	1	...	1	1	...	1	1	...	...	7	...
	3.8	...	...	1	...	...	...	...	...	...	...	...	...	1	1	1	...	...	...	...	1	3	...
	3.6	...	...	...	...	...	1	...	...	...	...	1	2	2	4	...	1	...	...	...	1	10	...
	3.4	1	...	1	...	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	3	1	...
	3.2	...	1	1	1	3	...	1	...	...	...	...	...	...	...	...	...	...	...	...	7	...	...
	3.0	...	2	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	2	2	...
	2.8	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
Totals	+	1	2	4	4	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	15	...	...
	0	...	1	...	...	...	1	...	...	1	1	1	4	3	6	2	1	1	1	1	1	...	24

TABLE IX
Correlation between index A and index B in (1090 × Kokati broad) M9

	Index A																Totals		
	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	+	?	50
4.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	2
4.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1
3.8	...	...	...	...	...	...	...	...	...	...	...	2	...	1	1	...	...	1	3
3.6	...	...	...	...	...	...	...	...	...	...	1	1	2	2	...	...	...	1	5
3.4	...	...	...	...	1	...	...	...	...	...	...	1	1	2	3	...	1	1	6
3.2	...	...	1	1	1	...	...	...	...	...	1	1	...	...	...	...	3	...	2
3.0	...	1	...	...	...	...	1	...	...	1	...	...	...	...	...	...	1	...	2
2.8	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1
2.6	...	2	...	3	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1
+	1	3	1	4	2	...	...	...	...	...	...	...	...	...	...	...	4	...	1
?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11	...	...
0	1	1	...	...	...	...	1	...	...	1	2	4	2	4	5	2	...	3	...
Totals	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	23

Index B

Totals

THE GENETICS OF A PETALOID MUTANT IN COTTON

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(Received for publication on 7th April 1938)

(With Plate XXXVIII)

INTRODUCTORY

MUTATIONS in cottons are not of rare occurrence. Several mutations have already been described by various workers, and the work on the genetics of such mutations has added a great deal to our knowledge of heredity of this very important plant. One mutation occurred at the Cotton Research Station, Lyallpur, and a record of its genetic behaviour is discussed in the present article.

The mutation in question was the occurrence of petaloid flowers in a pure strain of *G. arboreum*, *forma bengalensis* var. *sanguineum*, *neglecta* H & G. This pure strain had been grown at the Cotton Research Station, Lyallpur, for ten successive years from self-bred seed and had perfectly normal flowers. The mutation under discussion occurred, probably, during the year 1933, but was not detected until 1935. During this year the self-bred seed of one plant (06/34 P 12) was grown at Lyallpur and the natural seed of the same was grown simultaneously at the Cotton Research Sub-Station, Multan. The progeny of this plant at both the places exhibited three distinct types of plants, namely, with 'complete' petaloid flowers, intermediate flowers and normal flowers in a ratio approximately to 1 : 2 : 1. Since the number of the plants during this year was only 14 at Lyallpur, not much reliance could be placed on this ratio. The counting of plants of different types at Multan was, however, not done.

DESCRIPTION

The intermediate and the 'complete' petaloid plants are absolutely indistinguishable from the normal plants until the flowers open. In 'complete' petaloid plants almost all the stamens are transformed into structures resembling petals. Both the filaments and anthers are dilated to form such structures. This type of metamorphosis occurs right up to the top of the staminal column, leaving just a few normal stamens at the top. These few

anthers produce perfectly viable pollen. The ovules in all cases are normal and it is possible to make reciprocal crosses between the normals, 'complete' petaloid and the 'intermediate' plants.

In the intermediate plants the anthers are transformed into petal-like structures only on the lower half of the staminal column. The anthers on the upper half are normal and functional.

The plants with normal flowers are like ordinary plants in all respects.

The three types of flowers are represented in Plate XXXVIII.

LITERATURE

Saunders [1910-11] in *Petunia*, Gregory [1910] in *Primula sinensis*, Miyake and Imai [1928] in the Japanese Morning Glory and Ramanathan and Sankaran [1934] in cotton have reported double flowers being recessive to normal. Hutchinson and Ghose [1937] have, however, reported that the dominance of normal in the case of cotton is incomplete. The segregation in the F_2 generation of the double flower in *Primula sinensis*, Japanese Morning Glory and cotton has been reported to be in a monohybrid ratio, but in Stock a dihybrid ratio has been recorded.

EXPERIMENTAL RESULTS

From the mixed population of the 1935 crop, enough seed was selfed on the plants of all the three types, namely, normals, intermediates and 'complete' petaloids, in order to grow large progenies in the following year. Reciprocal crosses of normal $\times$ intermediate, intermediate $\times$ 'complete' and normal $\times$ 'complete' were also made. The self-bred seed obtained from the three types of plants and their reciprocal crosses was grown during 1936 and of their derivatives in 1937 and 1938. The analysis of the progenies from the Self-bred seed in the various years is given in Table I.

TABLE I

Classification of progenies of normal, intermediate and 'complete' petaloid plants

Year	Parent plant	No. of families grown	Total No. of population	Classification			Value of P of χ^2
				Normal	Intermediate petalody	Complete petalody	
1936	Normal	2	47	47	...	...	...
1937	Do.	1	18	18	...	...	...
1938	Do.	1	24	24	...	...	...
1936	Complete petalody	2	38	...	...	38	...
1937	Do.	2	67	...	...	67	...
1938	Do.	1	24	...	...	24	...
1936	Intermediate petalody	3	50	11	24	15	1:2:1=0.70
1938	Do.	6	399	106	203	90	1:2:1=0.7



Complete

Intermediate

Normal

Three types of flowers after removing the calyx and the corolla

It will be seen from Table I that the intermediate petaloid plants segregated in 1 : 2 : 1 ratio, while the 'complete' petaloid and the normal plants bred true. Further corroborative evidence for monohybrid segregation was forthcoming from the crosses the data for which are shown in Table II.

TABLE II
Segregation in the progenies of the crosses

Year	Cross	No. of families grown	Total No. of population	Classification			Value of P of χ^2
				Normal	Intermediate petalody	Complete petalody	
1936	Normal $\times$ intermediate petalody and reciprocal	4	230	126	104	...	1 : 1 = 0.15
1936	Intermediate petalody $\times$ complete petalody and reciprocal	2	114	...	64	50	1 : 1 = 0.2
1936	Normal $\times$ complete petalody and reciprocal	4	202	...	202	...	...
1937	Ditto	4	606	...	606	...	...
1938	(Complete petalody $\times$ normal) $\times$ normal	2	128	67	61	...	1 : 1 = 0.6

The evidence presented above shows that a single-factor difference was involved, but the dominance of the mutant character (complete petalody) over the normal was incomplete.

DISCUSSION

The results presented above show definitely that the mutant petaloid plants differed from the normals by a single factor. The origin of this mutation is not very clear. Since self-bred seed had been used for ten successive generations prior to the occurrence of the mutation, it can be assumed that the material was homozygous in most characters. It can, perhaps, be assumed that the parent plant of 1934 became heterozygous by mutation, and this escaped notice during 1934. In 1935 the segregation in a 1 : 2 : 1 ratio was detected.

The investigation reported here is of special interest in so far as the mutant petaloid condition is incompletely dominant over the normal flower. The investigators on the other plants have found such mutations recessive to normal. The dominance of 'normal' in the case of cotton has elsewhere been proved to be incomplete [Hutchinson and Ghose, 1937, 1]. The mutant plants, both male and female, are fertile and are able to set seeds.

Another important phenomenon noticed during this experiment was the weakening of the petaloid character with the advance of the season. In the beginning of the season when the plants were in the phase of active growth, the flowers were completely petaloid. As the season advanced, this character weakened and by the end of October the complete petaloid plants could be distinguished from the intermediate ones of a month ago with great difficulty.

This weakening of the petaloid character with the change in the season has already been reported by Miyake and Imai [1928] in Morning Glory. In cotton Hutchinson and Ghose [1937, 2] have also reported a similar phenomenon when the 'crinkled' *hirsutum* plants were grown inside the greenhouse. Thus the impact of the environmental conditions appears to have a far-reaching effect on these mutations. The explanation of this phenomenon can be found in the main mutating gene being attended by some modifying genes which find expression only in a limited set of conditions. This point is important and is worth noting in classifications of progenies for genetic analysis. If the analysis is made rather late in the season the distinction between full petaloid and intermediate is likely to be lost sight of and lead to misleading ratios of the different types. A similar case has already been reported by one of us [Afzal, 1937] where serious discrepancies were liable to occur in the ratios due to the classifications of the progenies being done at the wrong time.

Further work on this problem is in progress and the Madras petaloid in Karunganni cotton has been crossed with the Lyallpur petaloid. The data of this cross are so far incomplete and will be reported later.

SUMMARY

The mutation of double flower in cotton discussed in this paper is of incompletely dominant nature.

Both male and female gametes are normally functional even in the complete petaloid plants.

Petalody in cotton constitutes a single-factor difference to normal and the inheritance is in the ratio of 1 : 2 : 1.

Petalody becomes weak with the advance of the season, due, probably, to the interaction of modifying genes, which are effective only under a certain set of environmental conditions.

ACKNOWLEDGMENTS

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VARIATION IN *ASCOCHYTA RABIEI* (PASS) LAB., THE CAUSAL FUNGUS OF BLIGHT OF GRAM (*CICER ARIETINUM* L.)

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(With three text-figures)

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I. Introduction

THE investigations of the blight disease of gram (*Cicer arietinum* L.) caused by *Ascochyta rabiei* Pass (Lab.) which is very serious in the Punjab were started in 1926. The work done on the study of the life-history, modes of perpetuation of the causal fungus and measures of control of the disease has been already published [Luthra and Bedi, 1932; Sattar, 1932, 1933; Luthra, Sattar and Bedi, 1935]. The measures recommended to control the disease consisted in sowing healthy seed and destruction of diseased plant debris from the fields. But in order to check effectively the disease these measures have to be carried out thoroughly in cooperation by all farmers

in an affected locality. In practice, however, it has been found difficult to get them to adopt these methods. Under favourable conditions the disease has often assumed epidemic form and become widespread over gram-growing areas. Under these circumstances, therefore, the final solution of the problem of blight control was considered to be in the production of types of gram resistant to blight. In this connexion it was necessary, first of all, to find out if the gram blight fungus in the Punjab consisted of any biological strains. Work was, therefore, undertaken to study the strains of *Ascochyta rabiei*.

II. Experimental

I. MATERIAL AND METHODS

About 2,000 isolations were made from diseased material of gram, consisting of branches, pods, seeds and leaflets collected from different places—Campbellpur, Rawalpindi, Jhelum and Lyallpur. No indication was obtained that certain forms were exclusively confined to particular organs of the gram plant or to a particular locality. In all, six forms appeared to be distinct and these were included in the study. These are designated as A, B, C, D, E and F.

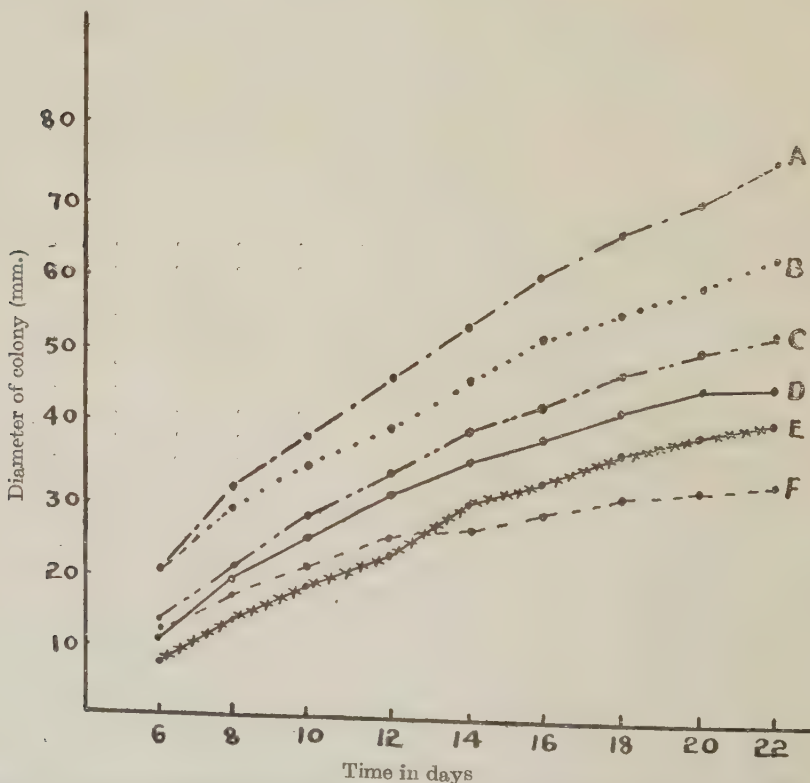


FIG. 1. Colony growth of the six forms of *A. rabiei* on Richards' agar at 20°C.

The following artificial culture media were used for growing the different forms. The nutrients were made up in one litre solution in distilled water :—

Oatmeal agar	.	.	.	Oatmeal 50 gm., and agar agar 20 gm.
Richards' agar	.	.	.	Sucrose 50 gm., KNO_3 10 gm., KH_2PO_4 5 gm., MgSO_4 2.5 gm. and agar agar 20 gm.
Nutrient glucose agar	.	.	.	Glucose 20 gm., peptone 10 gm., NaCl 5 gm., extract of meat 4 gm. and agar agar 15 gm.
Dolt's agar	.	.	.	Glycerine 5 gm., ammonium phosphate 1 gm., lactose 10 gm., and agar agar 15 gm.
Brown's agar	.	.	.	Glucose 2 gm., asparagin 2 gm., K_3PO_4 1.25 gm., MgSO_4 0.75 gm., and agar agar 15 gm.

2. STUDY OF THE SIX FORMS IN ARTIFICIAL CULTURE MEDIA

(A) Microscopic growth features

(i) LINEAR GROWTH RATE : *Effect of culture media.*—The six forms were grown on the five culture media at 20°C . and the diameter of colony of each form was recorded on every alternate day. The relative growth rate of the six forms on Richards' agar is shown in Fig.1 from which it will be seen that as regards diameter of the colony the different forms fall in the order A, B, C, D, E and F where A has the greatest linear growth and F the least.

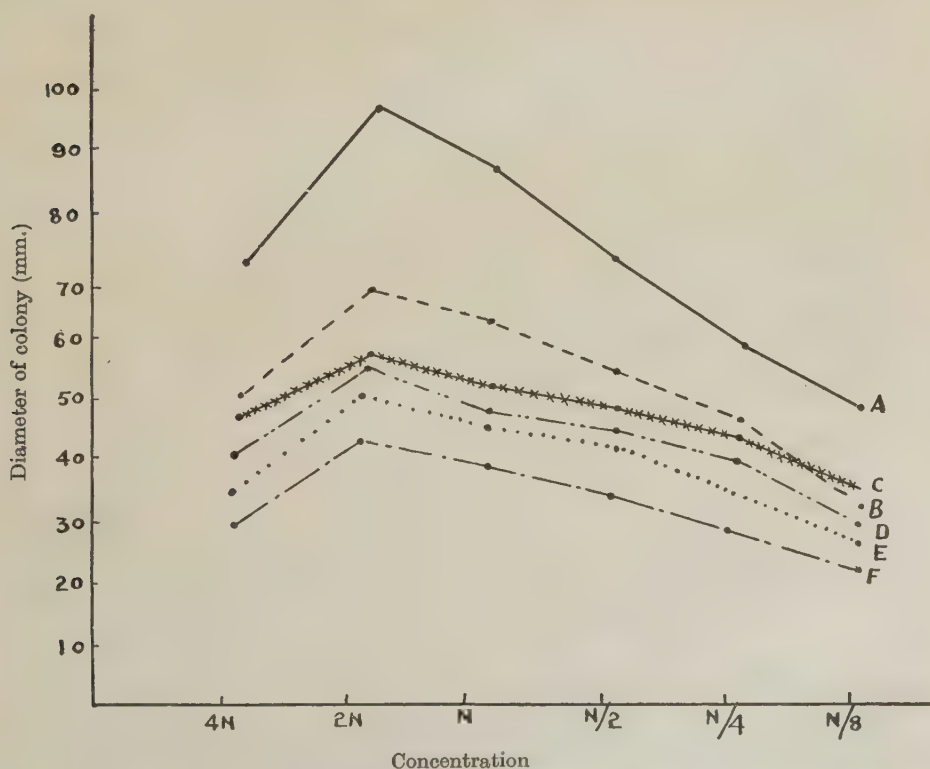


FIG. 2. Effect of concentration of culture medium (nutrient glucose agar) on colony growth of the six forms of *A. rabiei* at the end of three weeks at 20°C .

Similar curves were obtained for the linear growth of these forms on oatmeal agar, nutrient glucose agar, Dolt's agar and Brown's agar, showing thereby that all the forms are fairly distinct with regard to their growth rates.

Effect of concentration of the medium:—In order to test the effect of concentration of the medium, nutrient glucose agar was used. A range of concentrations from 4 N^* to $N/8$ was prepared and the six forms were grown at 20°C. The diameter measurements of colonies of each form at the end of three weeks on the various concentrations of the medium are shown in Fig. 2.

From Fig. 2 it is clear that all the forms have their maximum growth at 2 N and their growth above this point falls. At all the concentrations their order with regard to growth rate is the same as on different culture media referred to above except a slight variation at $N/8$ where B and C have changed places.

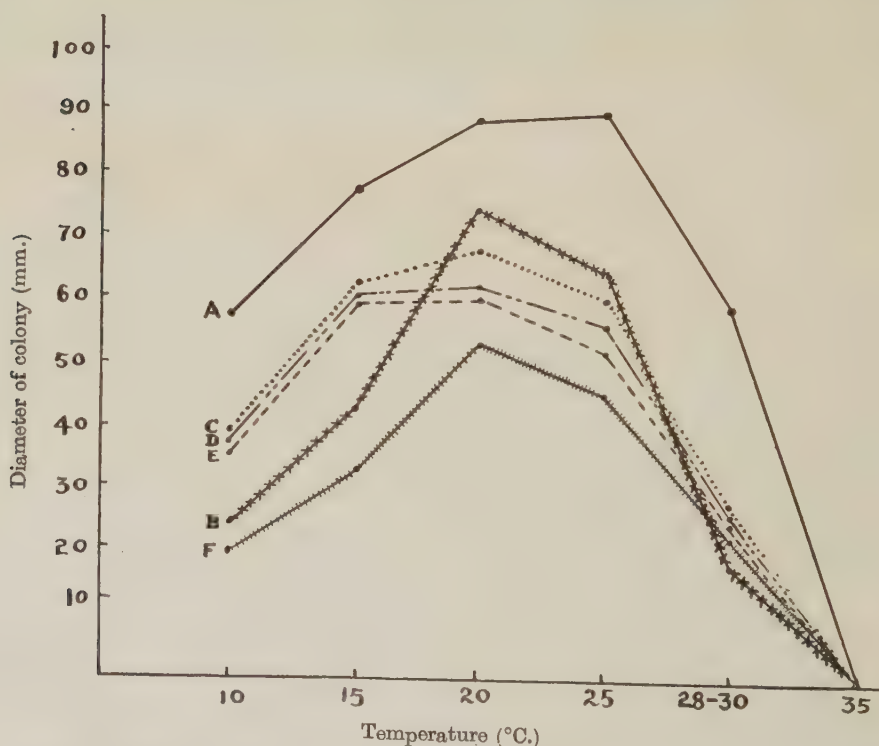


FIG. 3. Effect of temperature on colony growth of the six forms of *A. rabiei* on oatmeal agar at the end of three weeks

* N means normal nutrient glucose agar, $2N$ means double the quantity of the nutrients in 1 litre solution and $N/2$ means half the quantities of the nutrients in 1 litre solution and so on.

Effect of temperature.—The various forms were grown on oatmeal agar at 10°, 15°, 20°, 25°, 28°-30° and 35°C. for three weeks and the final colony diameter of each form is shown in Fig. 3.

From the results it is clear that the optimum temperature for growth of forms B, C, D, E and F is about 20°C. while that of A is about 25°C. and the maximum for all the forms is between 30° and 35°C.

Here again at all the temperatures the various forms excepting B arrange themselves in the same order with regard to growth rate as they do on the various media and on different concentrations of nutrient glucose agar referred to above. Form B maintains that order at 20°C. and 25°C., but at temperatures higher and lower than this range its growth falls more markedly than the other forms.

(ii) SPORULATION (PYCNIDIAL FORMATION): *Effect of culture medium.*—The relative amount of pycnidia formation of the six forms after three weeks' growth on different culture media is given in Table I from which it is clear that forms A and D are characterized by profuse sporulation, forms C and E are moderately fertile, while forms B and F are rather poor spore producers.

TABLE I

Relative amount of sporulation of the six forms on four culture media

Form	Richards' agar	Nutrient glucose agar	Dolt's agar	Brown's agar
A	++++	++++	+++	++
B	+	+	+	+
C	+++	+++	++	+
D	++++	++++++	++++	+++
E	++	+++	++	++
F	—	+	+	+

— = Absent, + = Scanty, ++ = Moderate, +++ = Good, ++++ = Very good, +++++ = Abundant.

Effect of concentration of medium:—The six forms were grown on different concentrations of nutrient glucose agar at 20°C. and the relative amount of pycnidial formation was recorded after three weeks. The results are given in Table II.

From the results given in Table II it will be seen that at *N* the sporulation of all the forms is the maximum, above this point sporulation decreases very rapidly so that at *2N* forms B and F do not produce any pycnidia and at *4N* all the forms excepting D remain sterile. Below *N* the amount of sporula-

tion decreases but not rapidly. It is noteworthy that at different concentrations of nutrient glucose agar just as on different media the forms B and F sporulate less abundantly than the other forms.

TABLE II

Relative amount of sporulation of the six forms on different concentrations of nutrient glucose agar

Form	4N	2N	N	N/2	N/4	N/8
A	—	+	++++++	++++	+++	++
B	—	—	++	++	++	+
C	—	+	++++++	++++	+++	++
D	+	+++	++++++++	++++++	++++	+++
E	—	+	++++	+++	++	+
F	—	—	Traces	+	++	+

— = Absent, + = Scanty, ++ = Moderate, +++ = Good, ++++ = Very good, +++++ = Abundant, ++++++ = Very abundant.

Effect of temperature:—The effect of temperature on sporulation is recorded in Table III from which it will be seen that the temperatures from 10°C. to 25°C. are in general favourable for pycnidial formation for all the forms. At 30°C. form A sporulates profusely, forms B, C and F remain sterile, while forms D and E produce scanty pycnidia. Here again it is clear that forms B and F are rather poor spore formers.

TABLE III

Relative amount of sporulation of the six forms on nutrient glucose agar at different temperatures

Form	10°C.	15°C.	20°C.	25°C.	29°C.	35°C.
A	++++++	++++++++	++++++++	++++++++	+++++	} No growth
B	+	+	++++	+++	—	
C	+++	++++++	++++++++	++++++	—	
D	++++++++	++++++++	++++++++	++++++++	+	
E	++++	++++++	++++++++	++++++	+	
F	—	+	++	+	—	

— = Absent, + = Scanty, ++ = Moderate, +++ = Good, ++++ = Very good, +++++ = Abundant, ++++++ = Very abundant, ++++++ = Super-abundant.

(iii) AERIAL MYCELIUM: *Effect of culture medium*.—The relative amount of aerial mycelium of the six forms on the four culture media at 20°C. at the end of three weeks is given in Table IV. It will be seen from this table that of all the forms, form B produces thick, profuse aerial mycelium on all the media tried, while the other forms are characterized by meagre or no development of aerial mycelium.

TABLE IV

Relative amount of aerial mycelium of the six forms on different culture media

Form	Richards' agar	Nutrient glucose agar	Dolt's agar	Brown's agar
A	—	Abundant to start with, but autolysed eventually. ++++	Abundant to start with, but autolysed eventually.	
B	+++		++	++
C	+	—	—	—
D	—	—	—	—
E	—	—	+	—
.	+	+	+	+

— = Absent, + = Scanty, ++ = Moderate, +++ = Good, ++++ = Very good.

Effect of concentration of a medium.—The relative amount of aerial mycelium of the six forms on different concentrations of nutrient glucose agar at 20°C. after three weeks' growth is given in Table V. Though at *N* and lower concentrations forms B and F only produce aerial mycelium, yet at *2N* and *4N*, the other forms also develop this character.

TABLE V

Relative amount of aerial mycelium of the six forms on different concentrations of nutrient glucose agar

Form	4N	2N	N	N/2	N/4	N/8
A	++++	+++	—	—	—	—
B	+++++++	+++++++	++++	++	+	+
C	++++	+	—	—	—	—
D	+	+	—	—	—	—
E	++	+	—	—	—	—
F	++++	+++	++	+	—	—

— = Absent, + = Scanty, ++ = Moderate, +++ = Good, ++++ = Very good, +++++ = Abundant, ++++++ = Very abundant.

Effect of temperature.—The effect of temperatures varying from 10 to 30°C. was studied on the production of aerial mycelium by the six forms. At all the temperatures form B produces profuse aerial mycelium, form F scanty, while the other forms do not develop any aerial mycelium.

(iv) COLONY COLOUR.—The colony colour of the various forms after three weeks' growth on different media at 20°C. at the end of three weeks is given in Table VI.

TABLE VI
Colony colour of the six forms on different culture media

Form	Richards' agar	Nutrient glucose agar	Dolt's agar	Brown's agar
A	Deep mouse grey to dark mouse grey	Almost black .	Pale pinkish buff before autolysis, pale flesh after autolysis	Pale mouse grey to light mouse grey, with a pinkish hue
B	Mouse grey to smoke grey	Greyish olive .	Deep olive buff	Smoke grey
C	Black . .	Black . .	Black . .	Black
D	Light pinkish cinnamon	Pinkish cinnamon	Pinkish buff .	Pinkish buff
E	Pallid mouse grey to deep mouse grey	Black . .	Olivaceous black	Black
F	Vinaceous pink	Pinkish buff .	Pinkish buff .	Vinaceous pink

It will be seen that though the culture medium exerts a noticeable influence on the colony colour, yet the change is of degree only and the various forms remain fundamentally unaltered on the different media, except form A which on three culture media, viz. Richards' agar, nutrient glucose agar and Brown's agar, produces almost the same colour, but on Dolt's agar exhibits different colour altogether.

(B) *Microscopic growth features*

Cultures of the six forms grown on oatmeal agar for three weeks at 20°C. were used for microscopic studies given below.

One hundred pycnidia and 100 pycnospores of each form were measured at random.

(i) PYCNIDIA.—Pycnidia of the different forms are generally round when single, but of irregular shape when in aggregation. The peridium consists of polygonal pseudo-parenchymatous cells. The ostiole may be present or absent in cultures. The pycnidia of forms A, B, C, E and F are deep olive in colour but those of D are pinkish buff. The size of 100 pycnidia of each of the six forms is given in Table VII.

TABLE VII

Size of pycnidia in microns of the six forms on oatmeal agar at 20°C.

Form	Range in microns	Mean in microns
A	30—240 × 30—210	116 × 100
B	105—330 × 105—270	207 × 188
C	75—330 × 60—300	181 × 160
D	75—480 × 75—480	250 × 223
E	90—375 × 75—300	219 × 197
F	45—285 × 45—225	132 × 119

The data on the size of pycnidia were examined statistically and the analyses of variance are given in Tables VII (a) and VII (b).

TABLE VII (a)

Analysis of variance of length of pycnidia

Due to	Degrees of freedom	Sums of squares	Mean square
Blocks	9	7325.95	813.99
Treatments	5	134154.02	26830.80
Error	45	38350.78	852.23
Total	59	179830.75	

TABLE VII (b)

Analysis of variance of breadth of pycnidia

Due to	Degrees of freedom	Sums of squares	Mean square
Blocks	9	6010.30	667.81
Treatments	5	111707.30	22341.46
Error	45	36293.50	806.52
Total	59	154011.10	

From Fisher's *z*-table it is clear that if the results are to be significant the mean square due to treatments should be at least 3.45 times the mean square due to error. Hence the results are highly significant in both cases. Further analysis of each form was made and the results are that as regards length of pycnidia, the differences between A and B, A and C, A and D, A and E, B and C, B and D, B and F, C and D, C and E, C and F, D and E, and E and F are significant, but the differences between A and F, B and E, and D and E are not significant. As regards breadth of pycnidia, the differences between A and B, A and C, A and D, A and E, B and D, B and F, C and D, C and E, C and F, D and F, and E and F are significant, while the differences between A and F, B and C, B and E, and D and E are not significant. Thus with regard to length of pycnidia, the forms can be grouped as follows:—

(i) A and F

(ii) C

(iii) B, D and E

With regard to breadth of pycnidia they fall into two groups:—

(i) A and F

(ii) B, C, D and E

(ii) PYCNOSPORES.—The pycnospores of all the forms are hyaline, generally single-celled, oval to oblong with muticle ends. About one per cent. pycnospores with a faint medium septum are observed in culture.

Size.—The size of 100 pycnospores of each of the six forms is given in Table VIII.

TABLE VIII

Size of 100 pycnospores of six forms on oatmeal agar at 20°C.

Form	Length in microns		Width in microns		$\frac{\text{Length}}{\text{Width}}$
	Range	Mean	Range	Mean	
A	5-10	8.1	3.5-5.0	4.0	2
B	4-17	11.78	2.5-6.5	4.68	2.5
C	4-16	10.01	3.0-6.5	3.95	2.5
D	4-24	11.56	2.5-6.5	4.0	2.8
E	4-16	11.28	2.0-6.0	4.29	2.6
F	3-18	12.68	3.0-10.0	5.23	2.4

The data on the size of pycnospores were examined statistically and the analyses of variance are given in Tables VIII (a) and VIII (b).

TABLE VIII (a)

Analysis of variance of the length of pycnospores

Due to	Degrees of freedom	Sums of squares	Mean square
Blocks	9	4.95	0.55
Treatments	5	121.29	24.25
Error	45	40.94	0.909
Total	59	167.18	

TABLE VIII (b)

Analysis of variance of the breadth of pycnospores

Due to	Degrees of freedom	Sums of squares	Mean square
Blocks	9	0.65	0.07
Treatments	5	10.38	2.07
Error	45	3.72	0.082
Total	59	14.75	

From Fisher's *z*-table it is clear that if the results are to be significant the mean square due to treatments should be at least 3.45 times the mean square due to error. Hence the results are highly significant in both the cases.

Further analysis of each form was made and the results are that as regards length of pycnospores, the differences between A and B, A and C, A and D, A and E, A and F, B and C, C and D, C and E, C and F, and E and F are significant, whereas differences between B and D, B and E, B and F, D and E, and D and F are not significant. As regards breadth of pycnospores the differences between A and F, B and C, C and F, D and F, and E and F, are significant, but differences between A and B, A and C, A and D, A and E

B and D, B and E, B and F, C and D, C and E, and D and E are not significant. Thus with regard to length of pycnospores the forms can be grouped as follows :—

- (i) A
- (ii) C
- (iii) B, D, E and F.

With regard to breadth all the forms are identical.

Shape.—The ratio length/width of the pycnospores of the six forms is given in the last column of Table VIII. This ratio is the smallest in form A. Therefore its pycnospores tend to be oval. Length/width in form D is the largest, therefore its pycnospores are somewhat rod-like and slender. Form F has the longest pycnospores which also have the greatest width and, therefore they tend to be more oval than oblong. Form C has its pycnospores intermediate both in length and breadth and thus most of its pycnospores are oval to oblong.

Germination.—Germination of pycnospores of all the six forms is negligible (only 1-2 per cent) in distilled water. They germinate well in $N/25$ to $N/100$ malic acid and thus the results already recorded by Sattar [1933] are confirmed. Gram leaf extract, which in addition to malic acid also contains some other nutrients, is better than malic acid for their germination but as the gram leaves are not available throughout the year and composition of gram leaf extract is variable, $N/50$ malic acid was used for germination tests. Data on the percentage of germination and length of germ-tubes are recorded in Table IX.

TABLE IX

Germination studies of the six forms in $N/50$ malic acid at 20°C . at the end of 16 hours

Form]	Percentage of germination	Percentage of bicellular spores	Average germ-tube length in microns
A	100.0	0.4	128.95
B	100.0	8.0	57.0
C	97.6	2.0	59.6
D	100.0	7.4	59.46
E	98.4	9.6	55.2
F	100.0	11.8	47.82

With regard to the mode of germination all the strains are almost identical. Germination was found to have commenced after four hours in nearly all the forms. By the end of eight hours a large percentage of spores had germinated.

It will be seen from Table IX that the length of germ-tubes of spores of form A is almost double that of spores of the other forms, which are almost identical in this respect. During germination about 2-12 per cent spores of forms B, C, D, E and F become bicellular but only 0.5 per cent pycnosporos of form A develop a median septum.

(iii) MYCELIUM.—With regard to colour of mycelium under the microscope the various forms fall into two distinct groups.

(1) Mycelium almost hyaline or colourless.

(2) Mycelium highly pigmented.

To group (1) belongs form D which has delicate and almost colourless and sparsely septate mycelium. To group (2) belong all the remaining forms. In the case of black forms A, C and E nearly the entire fungal mat consists of highly pigmented (deep olive to dark olive), closely septate and sparsely branching mycelium. In the case of forms B and F the aerial mycelium remains hyaline for some time but becomes deep olive in the end. However the compact fungal mat underlying the aerial mycelium is always dark.

3. PATHOGENICITY

For testing the pathogenicity of the various forms, potted gram (*Cicer arietinum*) plants of Punjab types 1-26 were inoculated by spraying spore suspension of the various forms. After inoculation the plants were kept covered for four days with disinfected glass bell-jars. All the forms except A produced infection on all the types of gram inoculated. Each form that caused infection was re-isolated from the diseased plants and it was observed that each form after having passed through the gram plant maintained its individuality. The symptoms and the amount of infection caused by the five forms, B, C, D, E and F on all the types of gram inoculated were similar. It therefore appears that the five forms B, C, D, E and F are biologically indistinct.

III. Discussion

The cultural as well as the morphological characters of the six forms A, B, C, D, E and F which have been studied are summarized in Table X.

From Table X it is evident that form A differs markedly from all the other forms, excepting F, in respect of size of pycnidia and from all the other forms in respect of length of pycnosporos, germ-tube length, linear growth rate, response to temperature and its non-pathogenicity on gram plants. This form, therefore, does not belong to the species *Ascochyta rabiei*. It only occurs as a saprophyte on gram.

TABLE X

Summary of the cultural and morphological characters of the six forms

Form Character	A	B	C	D	E	F
Linear growth on Richards' agar after 22 days in mm.	75	62	52	46	40	33
Optimum temperature for growth (°C.)	25	20	20	20	20	20
Sporulation . . .	Profuse	Poor	Moderate	Profuse	Moderate	Poor
Aerial mycelium . . .	Poor	Profuse	Meagre	Nil.	Meagre	Meagre
Colony colour . . .	Deep mouse grey	Mouse grey	Black	Pink	Mouse grey	Pink
Size of pycnidia in microns .	116×100	207×188	181×160	250×223	219×197	132×119
Size of pycnosporos in microns.	8.1×4.0	11.7×4.6	10.0×3.9	11.5×4.0	11.2×4.2	12.6×5.2
Septation of pycnosporos before germination.	100 per cent unicellular	99 per cent unicellular and 1 per cent bicellular	99 per cent unicellular, 1 per cent bicellular	99 per cent unicellular, 1 per cent bicellular	99 per cent unicellular, 1 per cent bicellular	99 per cent unicellular, 1 per cent bicellular
Percentage of bicellular pycnosporos after germination.	0.4	8.0	2.0	7.4	9.6	11.8
Germ-tube length in microns .	128.9	57.0	59.0	59.4	55.2	47.8
Pathogenicity on Punjab type (26) of gram.	Negative on all	Positive on all	Positive on all	Positive on all	Positive on all	Positive on all

The other five forms belong to the species *Ascochyta rabiei*. These are parasitic on the gram plant and produce the same symptoms. On morphological basis (length of pycnosporos and pycnidia) the form C can be distinguished from the other forms. The form C can also be distinguished from the other forms by the black colour of its colony. But the other four forms cannot be differentiated from one another. All the five forms are biologically identical. The authors, therefore, do not suggest that form C should be regarded a separate variety of *A. rabiei*.

IV. Summary

1. Six forms were isolated from diseased gram plants affected with *Ascochyta rabiei*. Detailed studies showed that five of these forms distinguished as B, C, D, E and F belonged to *Ascochyta rabiei* and one form designated as A occurred on gram plants as a saprophyte.

2. A comparative study of all the six forms has been made as regards the following :—

- (a) Morphology on the various artificial culture media,
- (b) Response to environmental conditions, such as nature of medium and temperature,
- and
- (c) Manner of spore germination,

3. Inoculation experiments with all the six forms have been done on potted gram plants and the result obtained is that form A is non-pathogenic, while the remaining five forms are parasitic on gram plant and produce the same symptoms.

4. The five forms B, C, D, E and F are biologically identical.

5. A discussion of experimental results in relation to the significance of these forms is given and the following conclusions are reached :—

(i) Form A does not belong to the species *Ascochyta rabiei* (Pass) Lab.

(ii) Forms B, C, D, E and F belong to the species *Ascochyta rabiei* (Pass) Lab. On morphological basis form C can be distinguished from the other forms, but the other forms cannot be distinguished from one another.

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STATISTICAL NOTES FOR AGRICULTURAL WORKERS

NOTE ON THE OPTIMUM SHAPE AND SIZE OF PLOTS FOR SUGARCANE EXPERIMENTS IN BIHAR*

BY

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IN CONJUNCTION WITH

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INTRODUCTION

THE influence of shape and size of plots on the accuracy of comparison is now well-established. Statistical analysis of uniformity trial data has shown that the optimum size and shape for field experiments depends chiefly on the distribution of the fertility gradient in the experimental area, as well as on the nature of the crop under test. Usually there is, however, a best plot size for each crop which is more or less the same for different localities unless there exist marked differences in the nature of the soil. Thus rice experiments in Bengal, Assam and even Ceylon show that the best plot size for variety trials lies between 1/40th and 1/80th acre. In sugarcane trials, Sayer, Vaidyanathan and Iyer [1936] found a plot size of 1/20th acre to be the most suitable for un-irrigated sugarcane; Sayer and Krishna Iyer [1936] observed that the percentage variation can be diminished by increasing the plot size up to 1/27th acre.

Another important point may be noticed here. In uniformity trials, the smallest plot size is almost invariably found to be the most efficient. But the smallest plot size is usually inconvenient for agricultural operations. Thus in a sugarcane experiment conducted by Mitra and Phukan in Jorhat (Assam) the highest precision was found for small plots containing only single rows, 13 feet long and separated from one another by 3 ft. furrows.

MATERIAL FOR THE ANALYSIS

The material for the present investigation was obtained from a variety trial experiment with four types of sugarcane, viz., Co 213, Co 210, Co 326 and Co 331, in Bihar. These were laid out in the form of a regular chess-board type of arrangement. The individual plots measured 45 ft. $\times$ 45 ft. and contained fifteen rows of plants each 45 ft. long, placed 3 ft. apart. At harvest the rows were divided into 15 units of length, each equal to 3 ft.; and the yield and number of canes in these units were recorded for the whole

* The work was carried out as part of the Sugarcane Research Scheme in Bihar financed by the Imperial Council of Agricultural Research to whom grateful thanks are due.

experiment. Each plot thus gave 225 readings of cane yield and another 225 readings of plant number, so that there were altogether 3,600 observations of cane yields and 3,600 of plant number.

ANALYSIS OF CONCOMITANT VARIATION

Fisher [1937] has shown that "the precision of an experiment may be greatly increased by equalizing, among the different treatments to be compared, certain potential sources of error". In the present investigation the yield in each row length of 3 ft. was noted along with the number of canes in the strip. An analysis of the number of canes shows that there are appreciable differences from strip to strip. Different parts of the experimental area were clearly exposed to various types of inequalities; in the first place, the soil fertility varied from one part to another; accidental injuries to plants were also of a local character. Assuming therefore that the number of cane is a measure of the inequalities present in the different strips, it is possible to increase the ultimate accuracy considerably. If there is no theoretical objection to comparing the yields of cane based on equal number of plants in the different plots, the method of study appropriate for this purpose is Fisher's Analysis of Covariance. This method has been adopted throughout in this paper. For a proper assessment of its potentialities the analysis of actual yield and of adjusted yield are both given side by side at every stage.

COMPARISON BETWEEN VARIETIES

The analysis of variance and covariance and of adjusted yields are given below in Table I.

TABLE I
Analysis of variance and covariance of the 4×4 Latin Square
 x = Cane number y = Cane yield

	D. F.	x^2	xy	y^2	Adjusted y^2	D. F.
Rows	3	51,086	70,879	1,04,136	..	..
Columns	3	29,288	40,021	70,188	..	..
Varieties	3	1,44,655	3,63,225	26,01,677	17,13,098	3
Error	6	26,256	38,946	98,165	40,398	5
Total	15	2,51,285	5,13,071	28,74,166	..	..
Variety + error	9	1,70,911	4,02,171	26,99,842	17,53,496	8

The mean values of cane number and of cane yield (actual and adjusted with standard errors) are given in Table II, for each variety.

TABLE II
Mean values of number and yield of cane

Variety	$\bar{x}$	$\bar{y}$	Adjusted $\bar{y}$
Co 213	1,916	3,498	3,726
Co 210	2,169	3,866	3,719
Co 326	2,074	3,648	3,642
Co 331	2,121	4,551	4,475
General mean	2,070	3,891	3,891
Standard error		63.96	44.94
S. E. per cent		1.64	1.15

The standard error of mean yield of a variety based on four replications has been decreased from 1.64 to 1.15 per cent of mean as a result of using the covariance between yield and number of canes. Hence the standard error per plot of size 45 ft. $\times$ 45 ft. (containing fifteen rows of plants of length 45 ft. each) is reduced from 3.28 per cent of mean to 2.30 per cent. The problem now is, how far the error of the experiment can be minimised by changing the shape and size of individual plots. For this purpose, we shall take up various shapes and sizes of plots by using different combinations of the unit row strips.

It should be noted here that the estimate of error for comparison of the varieties will not be unbiassed as the design of the main plots was of the systematic chess-board type, but the estimate of error for smaller plot sizes will be quite valid.

COMPARISON OF DIFFERENT SHAPES AND SIZES OF PLOTS

With the material of the present experiment, it is possible to estimate errors for 225 different shapes and sizes of plots by suitably combining the fifteen divisions of each row and the fifteen rows of each plot. In the present report we shall consider the analysis for twenty-five combinations of five row lengths (3, 9, 15, 30 and 45 ft.) with five numbers of rows (1, 3, 5, 10 and 15).

The analysis of variance and covariance for the minimum plot size are shown in Table III.

TABLE III

Analysis of variance and covariance for the unit plot-size "3 feet-one row"

	D. F.	x^2	xy	y^2	Adjusted y^2	Mean y^2	Mean adjusted y^2
Between plots	15	1,117	2,280	12,774	..	..	..
Within plots	3,584	46,897	90,038	1,82,580	9,715	50.9431	2.7114
	3,599	48,014	92,318	1,95,354			

The standard error of actual yield per plot of three feet row length is thus 7.14 lbs., and since the mean yield of plot size is 17.29 lbs., the error is 41.30 per cent of mean. The corresponding values for yield adjusted for plant number are 1.65 and 9.54 respectively. The reduction of error is very marked. The standard error in lb. per plot of all the twenty-five combinations are shown in Tables IV and IV (a).

TABLE IV

Standard error in lb. per plot for varying plot sizes

Actual yield

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	7.14	11.49	14.75	20.96	27.33
3	12.84	23.99	25.06	35.74	56.11
5	17.46	29.41	35.79	52.43	59.78
10	29.64	52.30	68.14	93.72	95.67
15	37.19	59.65	79.89	99.18	127.91

TABLE IV (a)

*Standard error in lb. per plot for varying plot sizes**Adjusted yield*

No. of rows	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	1.65	3.89	3.34	5.42	6.62
3	4.68	14.45	16.53	10.38	35.64
5	3.75	11.86	9.39	11.62	13.55
10	6.14	11.98	16.14	39.50	63.36
15	7.38	15.01	22.62	57.97	89.89

As the plot size increases, there is a more or less proportionate increase in the yields of individual plots. The actual standard error in lb. per plot naturally increases, but if these errors are expressed as percentages of their respective mean yields as shown in Tables V and V (a) it is found that the percentage variability between plots steadily diminishes as the plot size is increased. The same thing is more clearly seen from Tables VI and VI (a) where the errors have been expressed as percentages of the error of the smallest plot size (three ft. rows).

TABLE V

*Standard error per plot in per cent of mean**Actual yield*

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	41.30	22.15	17.06	12.25	10.54
3	24.70	15.42	9.56	6.96	5.75
5	20.20	11.34	8.28	6.13	4.61
10	17.03	10.02	7.83	5.44	3.66
15	14.34	7.67	6.16	3.86	3.29

TABLE V (a)

*Standard error in lb. per plot for varying plot sizes**Adjusted yield*

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	9.54	7.50	3.86	3.17	2.55
3	9.02	9.29	6.19	2.03	1.32
5	4.34	4.57	2.17	1.36	1.04
10	3.53	2.29	1.85	2.29	2.43
15	2.85	1.93	1.74	2.26	2.31

TABLE VI

*Standard error per plot as per cent of the standard error of the unit plot (three feet-one row)**Actual yield*

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 feet
1	100.00	53.63	41.31	29.66	25.53
3	59.81	37.34	23.15	16.85	13.92
5	48.91	27.46	20.05	14.84	11.16
10	41.23	24.26	18.96	13.17	8.86
15	34.72	18.57	14.92	9.35	7.97

TABLE VI (a)

*Standard error per plot as per cent of the standard error of the unit plot
(3ft.—one row)
Adjusted yield*

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	23.10	18.16	9.35	7.68	6.17
3	21.84	22.49	14.99	4.91	3.20
5	10.51	11.06	5.25	3.29	2.52
10	8.54	5.54	4.48	5.54	5.88
15	6.90	4.67	4.21	5.47	5.59

Thus with plots of one row only, the standard error of actual yield for row lengths of 3 ft. is as high as 41.30 per cent of mean; as the length is increased, the error diminishes and ultimately for 45 ft. rows, this is only 10.54 per cent of mean. With two rows per plot, there is again a steady diminution of error as the row lengths are increased but the rate of fall is a little lower than in the case of one row plots. A similar decrease will be noticed in all the other cases.

The standard error of adjusted yield also registers similar movement.

Again, if the length of rows is kept constant while the number of rows is increased, there is also a steady decrease of errors, but this is not so marked as that for the increase in row lengths. Justesen [1932], working with potatoes, also observed that a much lower standard error is obtained when the lengths of the plots are increased than when the widths are increased correspondingly. He attributes this to "slicing up" of local differences when long plots are used, so that the differences are more distributed over different plots than is the case when the plots are wider.

EFFICIENCY OF PLOT SIZE

We have seen that the relative variability diminishes as the plot size is increased; but as the total experimental area cannot be indefinitely increased, the number of replications with bigger plots is necessarily smaller. There are therefore two opposing factors at work in determining the final precision of a given plot size. If the size is bigger, there is a lowering of error and hence an increase in precision; but as replication is decreased, there is a diminishing precision, inversely proportional to the square root of the number of repetitions. To arrive at the effective error for comparison, therefore, we must multiply the standard error of a given plot size by the square root of the number of unit plots contained in it. This is shown in Tables VII and VII (a) expressed as per cent of effective standard error of actual yield for unit plot size.

TABLE VII

Effective standard error per plot as percentage of the effective standard error of the unit plot

Actual yield

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	100·00	92·91	92·42	93·80	98·81
3	103·59	112·02	89·66	92·29	93·83
5	109·36	106·35	100·22	104·93	96·65
10	130·37	132·87	134·07	131·70	108·57
15	134·47	124·83	129·13	114·51	119·49

TABLE VII (a)

Effective standard error per plot as percentage of the effective standard error of the unit plot

Adjusted yield

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	23·10	31·45	20·90	24·25	23·89
3	37·82	67·47	58·04	26·95	21·46
5	23·50	42·87	26·26	23·27	21·82
10	27·02	30·36	31·65	55·40	72·00
15	26·73	31·34	36·44	67·00	83·85

If we compare Tables VI and VI(a) with Tables VII and VII(a) we find that the larger plots are really not so efficient as they had appeared before. Thus in the case of actual yield if the effective standard error of the 3 feet-one-row plot is supposed to be 100, that for the 45 feet-one-row plot is nearly 99 per cent; but in Table VI, the two standard errors were 100 and 25·53 respectively. The reason for this is very simple: with 3 ft. rows, we may have fifteen replications within the same area as is required for one plot of 45 ft. row. Hence from the point of view of accuracy alone, there is not much to choose between plots of 3 ft. rows and 45 ft. rows.

Many workers have discussed the problem of effective errors in terms of efficiency. Thus Kalamkar [1932] defines "efficiency" as a quantity measuring the total information supplied for a given area. It is calculated by multiplying the variance per plot by the number of ultimate units contributing to the total of that plot and taking the reciprocal. Taking the efficiency of the smallest plot as 100, the efficiency of other plots is shown in Tables VIII and VIII (a).

TABLE VIII

Efficiency of plots of different shape and size relative to efficiency of unit plot
Actual yield

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	100.00	115.84	117.08	113.66	102.42
3	93.21	79.73	124.40	117.38	114.58
5	83.60	88.42	99.56	90.84	107.10
10	58.82	56.59	55.63	57.66	84.84
15	55.30	64.48	59.97	76.28	70.07

TABLE VIII (a)

Effective standard error per plot as percentage of the effective standard error of the unit plot
Adjusted yield

No. of rows	Length of rows				
	3 ft.	9 ft.	15 ft.	30 ft.	45 ft.
1	100.00	53.95	122.04	90.74	93.50
3	37.28	11.72	15.84	73.47	115.87
5	96.62	29.03	77.44	98.63	112.08
10	73.14	57.89	53.27	17.39	10.29
15	74.74	54.36	40.19	11.89	7.59

We notice from Table VIII that there is a marked fall of efficiency as the width of the plot is increased. It will be seen, however, that there is no marked fall of efficiency as the length of the rows is increased. Maximum precision is given by plots containing three rows each 15 ft. long.

But Table VIII (a) strangely enough condemns this plot size as one of the least precise. The two plot sizes which have come out consistently efficient in both Tables are each having length 45 ft. and width three rows and five rows. In fact, if smaller plots are difficult to work with, 45 ft.-five row plots with an area of 1/64th acre may be safely recommended for future trials.

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STUDIES ON THE HOT FERMENTATION PROCESS FOR THE COMPOSTING OF TOWN REFUSE AND OTHER WASTE MATERIAL

* II. SOME FACTORS INFLUENCING THE EFFICACY OF THE PROCESS

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(With one text-figure)

It is well known that the biological decomposition of plant materials is influenced greatly by factors such as the degree of moisture, temperature, the presence of available nitrogen, the degree of aeration, presence of inoculum, etc. These factors also influence the course of decomposition occurring in compost heaps ; and their importance is specially great in the hot fermentation process, since a special feature of this method is the intensive aerobic oxidation concentrated within the first five or six days, after which the mass is packed up anaerobically. It is, therefore, essential that the optimum conditions for rapid decomposition be known and secured even from the beginning.

The experiments described below were carried out under controlled conditions in concrete cisterns coated with cement inside so as to prevent leakage of the liquid constituents. Street sweepings and night-soil were used as compost materials and the influence of the following factors on the rate of composting were examined :—

- (1) Use of different proportions of soil, night-soil, leaves and moisture ;
- (2) temperature changes during composting ;
- (3) variations in the relative periods of preliminary aerobic and subsequent anaerobic fermentation ;
- (4) influence of added chemicals, e.g., calcium carbonate, superphosphate, sodium nitrate, ammonium sulphate and calcium cyanamide ;
- (5) comparison of the quality of composts prepared in cemented cisterns, underground pits and overground heaps ; and
- (6) influence of prior fermentation of street sweepings before the addition of night-soil.

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The composting procedure adopted was as follows :—

Town refuse was screened into two fractions : (1) consisting mainly of soil and ash constituents, and (2) consisting mostly of leaves and other organic matter. These, for the sake of brevity, will hereafter be denoted respectively as the soil and leaves fractions of town refuse. Large stones and other things such as glass, iron pieces, etc., were removed by hand.

The refuse materials used had the following average composition :—

TABLE I
Composition of refuse materials

	Street sweepings screened into		Night-soil (fresh) (per cent)
	Soil fraction (per cent)	Leaves fraction (per cent)	
Total carbon	3·07	30·71	9·30
Total nitrogen	0·24	1·23	1·10
Ash-free organic matter	6·20	54·30	15·30
Ash	91·30	36·10	4·20
Moisture	2·50	9·60	80·50

(All figures are on fresh basis including moisture.)

The requisite amounts of the soil and leaves fractions of street sweepings and of night-soil were weighed and mixed thoroughly on a brick-lined platform outside the containers, adding the necessary amount of water. The mass was then transferred into cisterns eight-cubic-feet made of concrete and coated with cement inside. A preliminary aerobic fermentation of five to six days was allowed, after which the contents were pressed down and packed anaerobically with a layer of mud-paste and then covered over with more earth. In some cases, the top was coated with a layer of cowdung. Anaerobic fermentation was allowed to proceed for $2\frac{1}{2}$ to 3 months, after which the manure was removed, weighed and representative samples taken for analysis. The remaining bulk of the manure was put back in the same cistern, under suitable cover, till required for manurial trials in pots or plots.

SAMPLING AND ANALYTICAL PROCEDURE

The complete contents of a cistern were removed, weighed and spread uniformly on a cowdung coated platform, so that the soil and leaves were uniformly distributed. A number of small samples were taken at different

spots and these were mixed together to form a composite sample for analysis. The sample was dried in the sun and powdered in a grinding mill before analysis. Carbon was determined by the wet combustion method of the author [Acharya, 1936] and total nitrogen by the Kjeldahl-Gunning method modified to include nitrates [A. O. A. C., 1935]. Ash-free organic matter was estimated by loss on ignition, after making an allowance for moisture present.

(1) Influence of soil on the humification of refuse materials

It was noted in some of the preliminary trials that the addition of soil to the compost heap helped to promote a more rapid disintegration and decay of the refuse materials. With a view to test this point further, trials were carried out with lots of 100 lb. of night-soil and 50 lb. of the leaves fraction of town refuse, and to this were added varying amounts of the soil fraction of street sweepings. Typical results that were obtained are shown in Table II.

TABLE II
Influence of addition of soil on the humification of town refuse

Compost lots : 50 lb. leaves + 100 lb. night- soil	No soil added		100 lb. soil added		200 lb. soil added	
Yield of manure (fresh)	126 lb.		312 lb.		505 lb.	
Yield of manure (sun dry).	58 lb.		150 lb.		260 lb.	
	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken
Carbon . . .	23.70	55.76	12.96	70.01	10.41	87.90
Nitrogen . .	1.70	57.65	0.88	67.70	0.68	80.74
Ash-free organic matter.	43.70	59.65	23.76	73.18	18.61	88.12

The data show that the addition of soil markedly increases the proportion of the original constituents (e.g. carbon, nitrogen and ash-free organic matter), which is ultimately recovered in the final compost. The increase in the recovery of carbon, for example, from 56 to 70 per cent when 100 lb.

of soil are added to a mixture of 100 lb. of night-soil and 50 lb. of leaves, and the increase of nitrogen recovered from 58 to 68 per cent implies a proportionate increase in the efficiency of the composting process due to the addition of soil provided, of course, the final material is well-formed compost. The addition of household ash contained in the soil fraction of street sweepings also serves to increase the manurial value of the compost in respect of potash and phosphoric acid.

The preliminary observations regarding the beneficial effect of soil in hastening the decay of the refuse materials were again confirmed in the subsequent experiments. This rapid decay was probably due to the combined effect of a number of factors, e.g.,

- (a) the soil forming an effective inoculum for the introduction of the necessary micro-organisms ;
- (b) the mineral constituents of household ash, associated with the soil fraction, acting as microbial stimulants ;
- (c) the retentive capacity of soil for moisture, helping to conserve moisture better in the compost heap and thus promoting better decay and decomposition ; and
- (d) the soil offering a buffer medium for keeping the reaction steady against the organic acids or ammonia that may be produced.

The smaller loss of organic matter in presence of soil may be explained as being due to the fact that the clay complex of the soil reacts with the constituents of the refuse material to form complexes which are more resistant to microbial decomposition than the original refuse constituents themselves. As such the decay is more physical than chemical. The influence of soil on the rate and course of biological decomposition of plant materials is well worth a detailed study. But it must be noted that the addition of large quantities of soil to the compost will markedly lower the organic matter and nitrogen percentage in the final manure obtained ; and the transport charges per unit of carbon and nitrogen will become proportionately higher.

Taking the above facts into consideration, it would appear advisable to add moderate quantities of the soil fraction, say 50 to 100 lb. for every 100 lb. of night-soil and 50 lb. of leaves, in the compost, so as to incorporate the advantages of the presence of soil, but not its disadvantages.

The addition of the soil fraction will also help to make up the shortage of leaf material felt in many municipalities for compost work.

(2) Influence of different amounts of night-soil

With a view to determine the maximum quantity of night-soil which could be decomposed with the help of a certain amount of leaf material, so that a manure free from night-soil odour could be ultimately obtained, composts were prepared in cisterns from lots of 50 lb. of leaf material and 100 lb. of soil

fraction, to which varying amounts of night-soil were added (Table III). The composting procedure was the same as that described before.

TABLE III
Influence of different proportions of night-soil

Compost lots : 50 lb. leaves + 100 lb. soil	Added 50 lb. night-soil		Added 100 lb. night-soil		Added 150 lb. night-soil		Added 200 lb. night-soil	
Yield of manure (fresh).	278 lb.		312 lb.		355 lb.		375 lb.	
Yield of manure (sun dried)	146 lb.		150 lb.		162 lb.		171 lb.	
	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken	Percentage analysis of sun dry material	Percentage recovery of constitu- ents originally taken
Carbon	10.01	63.35	12.96	70.10	15.01	75.14	17.18	79.36
Nitrogen	0.64	66.76	0.88	67.70	0.91	59.17	0.94	52.62
Ash-free organic matter	17.32	61.67	23.76	73.18	26.24	75.65	30.12	80.48

It was observed that composts to which amounts of night-soil greater than 100 lb. (for 50 lb. of leaves *plus* 100 lb. soil) had been added, smelt badly of night-soil, showing that the decomposition was only partial and that the bulk of the night-soil had only remained mechanically stored.

The analytical figures given in Table III show a higher recovery of carbon and of organic matter originally taken, with higher doses of night-soil; but there is a decreasing recovery of nitrogen above 100 lb. of night-soil. This shows that rapid loss of nitrogen takes place, probably as ammonia, when larger amounts of night-soil are composted with leaves and soil than what correspond to a ratio of 2 : 1 : 2.

(3) *Influence of leaves on the composting of night-soil*

It is the custom in several localities to make a poudrette of night-soil, by drying it either by itself or in admixture with soil. Under these conditions, there is very little biological decomposition of the night-soil and much of the nitrogen is lost due to liquefaction of the night-soil and the evolution of ammonia. In order to test the advantage of composting night-soil with leaves over the poudrette method, experiments were carried out with mixtures of soil and night-soil to which varying amounts of the leaves fraction of town refuse were added.

It was observed that poudrette, as ordinarily prepared, smelt strongly of night-soil, whereas the composts prepared by the addition of enough leaves and other decomposable organic matter, yielded well humified products without any offensive odour.

The analytical figures obtained are presented in Table IV. They show that the loss of nitrogen is greatest in cases where no leaves are added and also in others where excess of leaves are added. In the former case, the loss may be explained as being due to the absence of a vigorous microbial flora capable of fixing the ammonia evolved from night-soil. In the latter case, the carbon/nitrogen ratio of the compost tended to become narrow and thus resulted in loss of nitrogen.

TABLE IV.

Influence of leaves on the composting of night-soil

	300 lb. soil + 75 lb. night-soil. No leaves added		200 lb. soil + 75 lb. night-soil + 25 lb. leaves		100 lb. soil + 75 lb. night-soil + 50 lb. leaves		100 lb. soil + 75 lb. night-soil + 100 lb. leaves.	
Yield of manure (fresh)	420 lb.		405 lb.		335 lb.		390 lb.	
Yield of manure (sun dried)	298 lb.		220 lb.		156 lb.		179 lb.	
	Percentage analysis of sun dry material	Percentage recovery of original constituents taken	Percentage analysis of sun dry material	Percentage recovery of original constituents taken	Percentage analysis of sun dry material	Percentage recovery of original constituents taken	Percentage analysis of sun dry material	Percentage recovery of original constituents taken
Carbon . . .	4.42	81.41	7.42	78.52	11.42	70.18	14.17	62.24
Nitrogen . . .	0.31	59.99	0.51	70.13	0.74	69.11	0.72	56.13
Ash-free organic matter	7.84	77.87	14.02	82.47	20.22	70.41	25.77	64.16

It would appear that one part of leaves to two parts of night-soil (in presence of one to two parts of soil) would represent a suitable combination for ensuring rapid composting of the night-soil and at the same time for avoiding much loss of nitrogen.

(4) Water requirements for composting

A few experiments were carried out to determine the minimum water supply required for composting purposes by the hot fermentation process. This determination is of special importance in this method, since the mass is anaerobically packed after the first few days and no further additions of water are made during the $2\frac{1}{2}$ to 3 months period of anaerobic storage. In aerobic methods of composting, the moisture is generally maintained at about 50 to 60 per cent level by additions of water from time to time.

The experiments were carried out by adding varying amounts of water (3, 5, 7, 9 and 12 gallons of water) to a mixture of 50 lb. of leaf material, 100 lb. of soil and 75 lb. of night-soil, packed in cisterns according to the procedure already reported above. Assuming the water content of night-soil to be about 80 per cent, the relative proportions of dry matter and water added were as shown in Table V.

TABLE V

Water requirements for composting

Water added (additional)	Percentage moisture content of watered compost	Remarks
1 Nil	29.90	} Insufficient humification
2 1 gallon	33.06	
3 3 gallons	38.32	
4 5 gallons	42.81	} Satisfactory decomposition
5 7 gallons	46.69	
6 9 gallons	50.07	
7 12 gallons	54.41	} Liquid sludge at bottom, showing excess of water, bad sewage odour
8 15 gallons	58.06	

Taken 50 lb. leaves, 75 lb. night-soil and 100 lb. soil.

Dry matter in compost at start = 157.3 lb.

Moisture already present = 67.7 lb.

The moisture requirements under hot fermentation conditions would appear to be fairly well defined. Appreciable deficiency below this level prevented satisfactory rise of temperature in the early stages and hindered further decomposition during the succeeding anaerobic stage, whereas a too liberal dosage of water promoted anaerobic decomposition to such an extent as to form large amounts of ammonia and acid products.

Satisfactory humification of waste materials was secured in the above experiments by the addition of seven to nine gallons of water, *i.e.*, when the moisture content was brought to about 47 to 50 per cent calculated on the final weight of the watered compost. This amount of water was sufficient to bring about rapid aerobic decomposition and rise of temperature in the initial stages and subsequent anaerobic humification. Additions of water more than ten gallons left a good deal of water in the bottom of the cisterns at the end of the decomposition period, when the composts were opened. This happened in spite of the presence of 100 lb. of soil in the compost. The anaerobic decomposition in such cases was well advanced and the mass emitted a bad sewage odour. The liquid sludge at the bottom increased with the amount of initial moisture content above 54 per cent.

These remarks apply mainly to cases where the composting is carried on in brick-lined trenches or cisterns. Where, however, the trenches are not brick-lined, there is great danger of much of the valuable ingredients of night-soil being washed down, if the water supply exceeds an amount equal to that of the dry matter at the start.

It is interesting to compare the water requirement of the hot fermentation process with that of the aerobic methods. In both cases, the initial watering has to be done to bring the moisture content to about 50 per cent (i.e., proportion of dry matter : moisture = 1 : 1). In the hot fermentation process, no further additions of water are necessary, since the mass is compacted and anaerobically packed at the end of five or six days. But in the aerobic method, the compost is usually turned over and watered once a fortnight, at least four or five times. The amount of water that has to be added on subsequent occasions will, no doubt, vary with the weather conditions, but it can be roughly estimated that the total quantity of water required for the aerobic process will be three to four times that required for the hot fermentation method. The latter process will, therefore, prove specially valuable in areas of low rainfall or limited water supply.

(5) *Temperature changes during the hot fermentation process*

Daily readings of the temperature of the compost heap were taken at different depths, with the help of a long stem thermometer. The temperature increased up to a depth of 20-25 cm. from the surface, after which it decreased again. Typical variations of temperature over a number of days at three different depths in the compost, viz., 20 cm., 40 cm. and 60 cm. are shown graphically in Fig. I.

In general, it can be stated that the rise of temperature is proportional to the amount of decomposable organic matter present, e.g., leaves. Large amounts of water (above 50 per cent) hindered rapid rise of temperature. The maximum temperature (65-70°C.) was usually reached in about three to five days, after which the temperature slowly fell. The initial rise of temperature was conserved better in the system of packing in trenches adopted in the hot fermentation process than in the aerobic heaps overground, which permitted access of air from the sides and consequent cooling of the mass.

The high temperatures of 65-70°C reached in the initial stages served to destroy pathogenic organisms and weed seeds present in the compost heap. The fly larvae generally came to the top after the first day or two and were later destroyed when the heaps were covered over anaerobically with a layer of earth. The effectiveness of the destruction was shown by the complete absence of fly breeding, which is a common feature of other systems of composting night-soil and is a source of danger to public health in the surrounding area. Further, when the hot-fermented manure was later applied to land, the amount of weeds that developed was much less than when farmyard manure, as ordinarily obtained, was used.

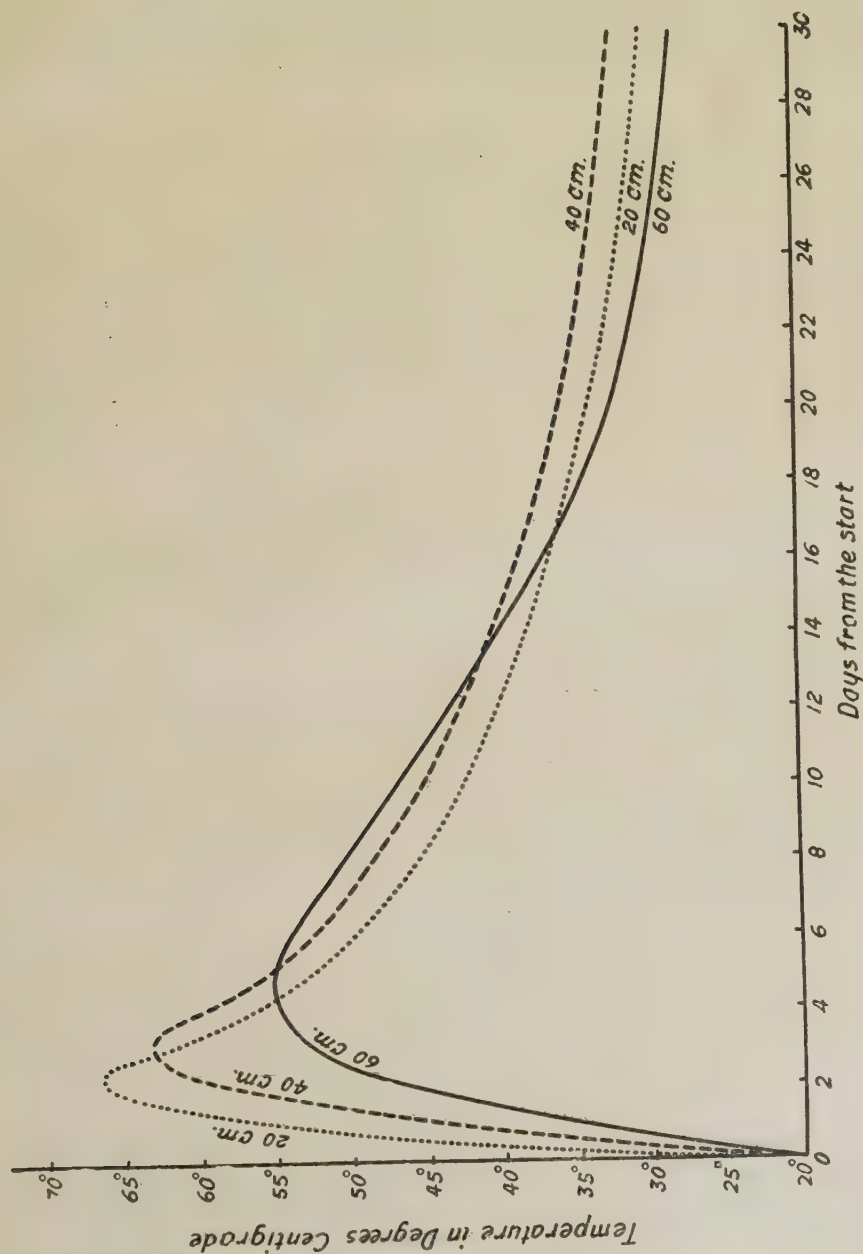


FIG. 1. Temperature changes at different depths of the compost heap

The initial high temperatures last for about four or five days after which the curves tend to come down. It is at this stage that the heaps are usually packed up anaerobically. Such packing helps to maintain the temperature at a high level for a long period and thus promotes thermophilic anaerobic decomposition.

(6) *Periods of preliminary aerobic and subsequent anaerobic decomposition*

A consideration of the temperature curves given above would show that very rapid chemical decomposition takes place in the first few days and the vigour of the reaction abates considerably after four or five days. In order to examine whether a similar picture is shown by chemical analysis at different stages of the decomposition, experiments were carried out with lots of 50 lb. leaf-matter, 100 lb. soil fraction and 75 lb. of night-soil. The recoveries of carbon and nitrogen expressed as percentages of the amounts originally taken, are given in Table VI.

TABLE VI

Period of preliminary aerobic treatment

Period of preliminary aerobic treatment (days)	Temperature (°C)	Percentage recovery of carbon	Percentage recovery of nitrogen
1 . . .	55	92.1	89.4
2 . . .	65	84.8	82.1
3 . . .	62	79.3	77.6
5 . . .	54	75.6	74.3
7 . . .	50	74.4	72.1
10 . . .	44	72.9	71.6
15 . . .	40	70.7	69.4

The figures show that chemical analysis confirms the temperature indications, viz., that the bulk of the decomposition takes place within the first week and that the subsequent change proceeds more slowly. But, since the mass is compacted free from further access of air after the first five or six days, the subsequent anaerobic change may be expected to be much slower still and to consist mainly of a process of humification, without appreciable loss of carbon or of nitrogen.

This was tested by a further series of compost lots of 50 lb. leaf-material, 100 lb. of soil fraction and 75 lb. night-soil, which were kept aerobic for five days and then were packed anaerobically in cisterns. The cisterns were opened at periodical intervals, the contents weighed and representative samples taken for analysis. The data obtained are presented in Table VII.

TABLE VII
Period of anaerobic packing

Period of anaerobic packing after preliminary aerobic treatment for five days									Percentage recovery of carbon	Percentage recovery of nitrogen
<i>Nil</i>	.	.	.	.	.	.	.	.	74.4	72.1
1 month	.	.	.	.	.	.	.	.	72.1	70.6
2 months	.	.	.	.	.	.	.	.	70.9	70.2
3 months	.	.	.	.	.	.	.	.	70.1	69.6
4 months	.	.	.	.	.	.	.	.	69.6	69.1
6 months	.	.	.	.	.	.	.	.	69.0	68.4

It may be rather misleading to interpret the data given above as indicating that it is unnecessary to subject the mass to the subsequent process of anaerobic decomposition. Though this second stage does not result in any appreciable net loss of carbon or nitrogen, it does signify a period of important anaerobic transformations proceeding in the mass whereby the compost is well humified and its nitrogen is rendered more easily nitrifiable and available to the plant. A period of two to three months' storage is necessary before the manure can be considered ready for application to land.

(7) *Influence of the addition of chemicals on the course of decomposition*

It is well known that the biological decomposition of plant materials is greatly influenced by the reaction of the medium, by the presence of nitrogenous starters such as calcium cyanamide, ammonium sulphate or sodium nitrate and by the addition of chemicals such as superphosphate, potash, etc.

Experiments were carried out on the usual lines with compost lots of leaves, soil and night-soil, in order to test the effect of the addition of the above substances. The reaction was sought to be maintained (a) on the neutral or slightly alkaline side by addition of lime; and (b) on the acid side by the addition of molasses, which, under anaerobic conditions rapidly ferments to organic acids.

No beneficial effect was noticed due to the addition of lime, probably because the soil fraction used in the compost contained already a good amount of household ash, which is alkaline. Further, the night-soil present in the compost tends to become alkaline due to liberation of ammonia, which serves to neutralise any organic acids formed in the anaerobic stage. The soil also acts as a good buffer medium.

The addition of nitrogenous starters such as ammonium sulphate and calcium cyanamide had also no effect, showing that night soil was a sufficiently powerful starter by itself and does not stand in need of supplements. Superphosphate had also no beneficial effect, probably due to the fact that the ash constituents present in the soil fraction supplied the necessary amount of phosphoric acid for microbial activity.

Sodium nitrate and molasses, however, yielded interesting results. In the former case, the recoveries of both carbon and nitrogen were markedly decreased (Table VIII). It is well known that sodium nitrate, in addition to being denitrified under anaerobic conditions, is a good source of oxygen for the oxidation of other substances present along with it under such conditions [Acharya, 1935]. It is, therefore, not surprising that in addition to losing the whole of its own nitrogen, it brings about the loss of nitrogen already present in the night-soil added to the compost. It is doubtful whether sodium nitrate, on account of the ease with which it can be leached out and other disadvantages, could be recommended as a starter for composting work under any conditions even including aerobic.

TABLE VIII

Influence of added substances on composting

Substance added	Percentage recovery of carbon	Percentage recovery of nitrogen
(1) Control without any addition	70.18	69.11
(2) Added 10 lb. NaNO_3	55.62	39.59
(3) Added 40 lb. molasses	59.14	80.42

(Compost lots ; 50 lb. leaves ; 100 lb. soil and 75 lb. night-soil.)

In this connection, it may be noted that any nitrate present in the compost at the start is likely to behave similar to sodium nitrate and is likely to be lost in the hot fermentation method. It is, therefore, advisable to see that the initial period of aerobic decomposition is just enough to oxidise the easily decomposable constituents of the compost and is not prolonged so as to form nitrate. Under the conditions of the composting procedure described above, where the compost heap is packed up anaerobically when the temperature falls from 65° to 50 °C., it is doubtful whether nitrification (optimum temperature 30-35°C.) would have begun. Hence no loss of nitrogen need be feared on this account in the present method.

In the case of molasses, the figures show a lower recovery of carbon but a higher recovery of nitrogen originally taken to start with. This can be

explained as due to the fact that (a) molasses, in addition to being easily oxidised itself, serves as a source of energy for the oxidation of other substances ; hence the recovery of carbon is low ; and (b) molasses yields a good amount of acids which serve to fix the nitrogen of the night-soil, which otherwise would have been lost as ammonia ; hence the recovery of nitrogen is higher than in the control. It is doubtful, however, whether the use of molasses for this purpose would be a practical proposition on account of its cost and transport charges.

(8) Comparison of different methods of packing the hot fermentation compost

The experiments described above were all carried out under controlled conditions in concrete cisterns which were cement-coated to prevent any possible seepage of the liquid contents. But since, on the large scale, the preparation of such cisterns would be uneconomical for purposes of composting, other types of containers were tried which would be cheaper.

It has already been stated that the temperature of the composting mass is conserved better in underground trenches or cisterns than in heaps overground, which are exposed to air on all sides.

The following types of packing the compost were compared:—

- (1) Concrete, cement-coated cisterns 2 ft. $\times$ 2 ft. $\times$ 2 ft. of the type used in the previous experiments ; these were over ground.
- (2) Trenches, dug in the ground, 3 ft. $\times$ 3 ft. $\times$ 20 ft., which were lined with brick and plastered.
- (3) Similar trenches, underground, which were not brick-lined or plastered.
- (4) Heaps overground on brick-lined and plastered platforms.
- (5) Heaps over ordinary ground which was hardened and coated with a thick layer of cow-dung, but without any brick-lining or plastering.

In all cases, the proportion of the leaf-matter : soil : night-soil was 50 : 100 : 75, though the actual amounts used varied with the size of the containers. At the end of six days, when the temperature was falling, the heaps were compacted and covered over with a layer of earth and plastered over with cow-dungmixed with water. The heaps were re-opened at the end of three months, weighed and analysed.

The recoveries of carbon, nitrogen and ash-free organic matter are shown in Table IX.

TABLE IX

Comparison of different methods of packing the hot fermentation compost

Percentage recovery of amounts taken at the start	Concrete cisterns cement-coated (over-ground)	Trenches brick-lined and plastered (under-ground)	Trenches without brick-lining (under-ground)	Heaps over-ground on brick-lined platforms	Heaps over-ground without brick-lined platforms
Carbon	70.18	76.96	58.12	62.81	51.13
Nitrogen	69.11	74.16	59.22	64.62	54.57
Ash-free organic matter	70.41	78.81	57.58	61.46	53.50

The figures show that the highest conservation of carbon and nitrogen is obtained in brick-lined trenches underground, followed respectively by systems of packing 1, 3, 4 and 5 mentioned above. The low value obtained for heaps overground, without a brick-lined platform, was, no doubt, due to seepage of the constituents into the underground layers, especially when there was heavy rainfall. The heaps on brick-lined platforms analysed better, but these were poorer in carbon and nitrogen than the composts made in brick-lined trenches, probably due to continued aeration of the overground mass in the later 'anaerobic' stage, in spite of the mud covering.

It was observed during the experiments that the manure prepared in the underground trenches—both brick-lined and without brick-lining—had humified better and contained larger quantities of fungal matter than the composts prepared in concrete, cement-coated cisterns overground. This was probably due to the fact that the much bigger mass of compost packed in the former case produced a better rise of temperature and a more advanced stage of humification than in the latter.

The composts prepared in underground trenches, without brick-lining, lost, no doubt, some of the nitrogenous components due to leaching (since the nitrogen recovery is poorer than in trenches with brick-lining), but they were better than the composts prepared in heaps overground. The adoption of underground trenches without brick-lining is, however, limited to areas where the water-table is not too high, since in the latter case, the loss of nitrogen will be specially heavy. In cases where the water-table is high, it would be essential to brick-line and plaster the sides of the trenches; otherwise, overground cisterns or overground heaps on brick-lined platforms would have to be adopted.

(9) Effect of prior fermentation of leaf material before addition of night-soil

It will be noticed from the data presented in the above tables that a good percentage of nitrogen (from 25 to 30 per cent) is lost while composting night-soil even by the hot fermentation process. It was felt that the loss might have taken place as ammonia, on account of the rapid liquefaction of night-soil. Attempts were made to secure a higher conservation of nitrogen by subjecting the leaf material to a preliminary anaerobic decomposition so as to form organic acids which might later help to fix the ammonia evolved from night-soil.

The experiments were conducted with lots of 50 lb. screened leaves fraction plus 100 lb. of soil fraction which were sprayed on with water to bring the moisture level to 50 per cent. and allowed to decompose in covered cisterns for four or five days. At the end of this period, 75 lb. of night-soil were added to each lot and then one series was kept aerobic and turned over once in ten days while the other was subjected to the hot fermentation process as described before.

In order to increase the amount of acids formed during the initial anaerobic decomposition, another series was run on the above lines by the hot fermentation procedure, with the difference that 10 lb. of molasses were added to the leaves fraction at the start.

The recoveries of carbon and nitrogen obtained in the different cases are shown in Table X.

TABLE X
Influence of previous fermentation of leaves

	Lots of 100 lb. leaves, 50 lb. soil and 75 lb. night-soil	Aerobic process		Hot fermentation process	
		Percentage recovery of carbon	Percentage recovery of nitrogen	Percentage recovery of carbon	Percentage recovery of nitrogen
1	Without preliminary fermentation of leaves	51.42	56.28	70.18	69.14
2	With preliminary fermentation of leaves	47.61	52.14	68.61	70.22
3	Preliminary fermentation of leaves with 10 lb. molasses	42.48	60.26	62.38	77.46

The figures show that there is no appreciable gain due to the preliminary fermentation of leaf material. This might have been due to the fact that not much of acidity was produced during the decomposition of leaf material, which was already rich in nitrogen (1.23 per cent). The recovery of nitrogen

is better where molasses had been added at the start, but, as has been already observed, the addition of molasses for the purpose will not be an economic proposition. Moreover, the addition of molasses serves to depress the recovery of carbon on account of its functioning as a readily available source of energy for oxidation purposes.

SUMMARY

Experiments carried out under controlled conditions with street sweepings and night-soil in order to examine the influence of various factors on composting the above materials by the hot fermentation process showed :

1. The addition of soil—especially the screened soil *plus* ash fraction of street sweepings—to a mixture of night-soil and leaves, promoted a more rapid disintegration and decay of the compost material and decreased the loss of nitrogen and of organic matter. Addition of large amounts of soil, however, decreased the manurial value of the compost.

2. In the absence of leaves and other easily decomposable fractions of street sweepings, the mixture of night-soil and soil decomposes slowly and most of the night-soil remains as such in the dry condition. The resulting poudrette of soil and night-soil smells badly of night-soil.

3. An optimum mixture for composting purposes would consist of one part by weight of leaves fraction of street sweepings, one to two parts of the soil fraction and two parts of night-soil.

4. An initial moisture content of about 50 to 55 per cent in the compost heap at the start is optimum, and further additions of water are unnecessary in the hot fermentation process. A moisture level less than 40 per cent results in insufficient humification and a level higher than 55 per cent leads to the formation of liquid sludge at the bottom and loss due to seepage.

5. The water requirements of the hot fermentation process are much less—about a third or fourth—than for ordinary aerobic methods of composting.

6. Temperature measurements made at different depths and on different days showed that the temperature rapidly rose from the second day and reached a maximum of about 65° to 70°C. on the third or fourth day, after which it slowly fell. The temperature increased from the outer layers inward till a maximum was reached at a depth of about 20 cm. in the earlier stages and at a depth of about 40 cm. in the later stages of composting.

7. The bulk of the decomposition in the hot fermentation system takes place during the preliminary aerobic treatment of five or six days ; the loss in weight in the subsequent period of anaerobic decomposition is very small.

8. No beneficial effect was noticed due to the addition of lime or superphosphate to the compost of night-soil and street sweepings. The addition of nitrogenous starters, such as calcium cyanamide, sodium nitrate or ammonium sulphate, was also unnecessary where night-soil was present, and only served

to increase the total loss of nitrogen. Sodium nitrate, on account of its oxidising action, also served to increase the loss of organic matter. The addition of molasses served to decrease nitrogen loss, but increased the loss in organic matter.

9. A comparison of different containers for carrying out the hot fermentation method, *viz.*, (a) concrete, cement-coated cisterns ; (b) underground trenches which are brick-lined and plastered ; (c) underground trenches without brick-lining ; and (d) overground heaps on un-brick-lined platforms, showed that there was considerable loss of nitrogen and of carbon, apparently due to seepage, in cases where the trenches or platforms were not brick-lined. Between overground heaps and underground trenches, the latter promoted more 'uniform' decomposition of the material and conserved the manurial constituents better.

10. Prior fermentation of street sweepings anaerobically for a few days before adding night-soil did not materially decrease the loss of nitrogen. The addition of molasses, however, to the fermenting street sweepings, decreased the loss of nitrogen when night-soil was subsequently added, but the gain was not worth the additional expense involved.

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RELATION OF GROWTH TO FRUIT BEARING IN MANGOES

BY

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I. Introduction

IRREGULAR or biennial bearing in the mango is a well-known phenomenon and hardly needs any explanation. As far back as 1590, Abul Fazal, author of the *Aini-Akbari*, an encyclopedic work, while giving an account of this fruit, mentioned that some trees yielded in one year a rich harvest and less in the next, while others yielded for one year and produced no fruit at all in the following year. Similarly Hartless [1913] writes that he had never heard of any variety of mango that flowered normally every year. Burns and Prayag [1920] have mentioned that the record of the mango crop from 1908-16 taken from Ganeshkhind Botanical Gardens on the whole confirmed the belief that the mango tree bears a heavy crop only in every alternate year and that in the intervening year the crop is poor.

The bearing habit of the tree in alternate years is so regular that the 'off' and 'on' year can be anticipated almost with certainty, unless, of course, it is altered by some unforeseen circumstances, such as unfavourable climatic conditions—frost, hailstorm or untimely rain at the time of flowering or incidence of some disease or pest. The problem is of great economic importance to the fruit growers as in the 'on' year, due to the abundance of the crop, the markets are glutted with the fruit and in consequence the price realized is low and unremunerative whilst in 'off' years the growers are confronted with very little crop to offer for sale when the prices are high. To obtain, therefore, a profitable income from a mango orchard it is very essential that the trees during their entire productive life should produce a reasonably regular crop each year. To attain this object it is very necessary to understand the growth behaviour of a tree as influenced by climatic conditions and cultural practices and correlate such growths to fruit bud formation. Once a certain type of growth, its behaviour during the growing season as well as its relationship with productivity or otherwise, are all clearly understood, this should serve as a guide to a grower for securing a desirable type of growth by adopting cultural practices most suited for the purpose. Growth response which a tree gives, although morphological in nature, is nevertheless an expression of the condition in the cell or tissue brought about by external and internal factors and can serve as a convenient and simple guide for predicting the future behaviour of the plant.

As growth behaviour of mango tree is rather peculiar, a brief account of the same under Lyallpur conditions would be desirable. Unlike many other fruits the growth in mango in the course of a season is periodic rather than continuous, i.e. successive periods of growth alternating with quiescence. These periodic growths are usually termed as flushes. The number of flushes occurring during the growing season in a year as well as the date on which they occur and the period over which they extend varies with the variety, climatic conditions, cultural practices, age of the tree and the amount of the crop borne by the tree. Yet under Lyallpur conditions in Langra mango growth initiation takes place practically during each month commencing from April and ending with August and consequently as many flushes as five may be

produced during the growing season. Each flush, after it is initiated, grows for some time, stops and breaks out again till the growth finally ceases. The amount of growth produced by each flush in different years is again very variable, in some years it is more while in others it is less.

The flower panicles are borne terminally on the last season's growth only and consequently once a shoot has borne flowers or fruit it does not grow from the terminal bud, but the growth, if any, is made from the lateral buds. Again seasonal elongation of growth has a direct bearing on fruit bud differentiation but no work of the type has so far been done on this fruit. Numerous workers from time to time have studied the growth behaviour to fruitfulness in other fruit trees. Gourley [1915], Edminster [1917], Heinicke [1917], Roberts [1920, 1926], Maney and Plagge [1921], Hooker [1925], Dorsey and Knowlton [1925] and Swarbrick [1928], working on apples, have pointed out the importance of individual shoots or spurs in relation to fruit bud formation. All these investigations emphasize the importance of the relationship between growth characters and fruiting potentialities in applied plant physiology in horticulture.

In order to study the relationship between various kinds of growth and productivity and to elucidate some of the growth conditions responsible for alternate bearing in the mango tree, a good deal of data has been collected during the years 1932 to 1938. It may be mentioned that due to lack of suitable material, the investigation could not cover several other phases, such as manuring, irrigation, ringing, pruning and carbohydrate-nitrogen ratio and its bearing on the vegetative growth, fruit production, etc., but it is gratifying to note that the extensive data so far collected have given some definite and valuable information in regard to the behaviour of various types of growth and their relation to fruiting in the following year, as well as the cause of alternate bearing and how this habit could be averted. The aim of the present paper is to deal with the findings of the investigations to date since the inception of the experiment.

II. Procedure and material employed

This paper deals with the investigations extending over a period of six years, the data having been collected by several workers. The investigations started in 1932 when the data were collected by K. C. Naik. During 1933-34 performance records were taken by K. C. Naik and Abdul Aziz Khan. In 1934-35 growth measurements were taken by Pritam Singh Diol, but owing to the occurrence of frost in January 1935, the fruit buds were totally damaged and consequently the data could not be utilized. In 1935-36 the growth performance and flowering records were taken by Abdul Aziz Khan and in subsequent years by Sangat Singh.

Full-grown grafted Langra mango trees, apparently uniform with regard to their size, vigour and productivity, were selected for this investigation in the Mango and Date Avenue at the Punjab Agricultural College, Lyallpur.

The trees included in the trial have all been raised by enarching over mango seedlings of unknown origin. This, no doubt, introduces an element of uncertainty as regards rootstock, but as all grafted mangoes are almost exclusively propagated by this method, it is believed that the results obtained would fairly represent the conditions in mango plantations in the Punjab.

These trees are growing under practically uniform conditions of soil since their planting in 1913. None of these have ever been pruned and in other respects also they have been receiving fairly uniform treatments. From six Langra mango trees 134 and 120 shoots, initiated on the previous year's growth in the months of April and June 1932, respectively, were selected at random. The shoots at the top of the trees being very high and not within easy reach of the recorder were not included during this year, though in subsequent selection of new shoots this was also done. These were numbered and labelled and designated as April and June flush shoots. Growth measurements from the previous year's leafscar of each individual shoot were started as soon as any noticeable enlargement of the growth took place and were recorded every week in halves of centimetres throughout the growing season till the period of quiescence when the growth indicated no further enlargement. In the spring of 1933, behaviour of individual shoots with respect to their bearing or non-bearing was noted and the means of the seasonal elongation growth of both bearing and non-bearing shoots under each flush were computed. Again the performance records of these shoots with respect to their growth at monthly intervals were taken in the growing season of 1933 and the bearing and non-bearing shoots out of these were again recorded separately in the spring of 1934 and their means of seasonal elongation compiled on the lines explained already. It would appear, therefore, from the above that the performance records of the shoots selected in 1932 were continued up to the spring of 1934 after which period these were discarded on account of injury caused to them by frost in 1935.

In the spring of 1935 only one tree was taken upon which shoots initiating at different times of the growing season were selected at random and these shoots were designated as April flush, May flush, June flush, July flush and August flush shoots according to the month in which they started to grow. The number of shoots belonging to July and August flushes was rather small but this could not be helped as these were the only shoots in their respective categories produced by the entire tree. Special precautions were taken to select these flushes on the previous year's growth, to eliminate the chance of selecting shoots, in the later part of the growing season, on the earlier flushes and designating these wrongly. As a matter of fact, they may be the continuations of the flushes produced in the beginning of the growing season. The performance records of these shoots were continued to be taken up to the spring of 1938 on the lines already explained.

In addition, 120 flowering shoots were selected on the same tree in the spring of 1935 out of which 20 were deblossomed intentionally early April, while seven others were accidentally deblossomed. The performance of the deblossomed shoots was maintained till the spring of 1938,

In 1937 fresh shoots were selected from a single tree again, this tree being different from the one included in the trial in the spring of 1935. In the spring 100 shoots each of April, May, June, July and August flushes were labelled and their growth performance continued at fortnightly intervals till the shoot elongation had finally ceased. In 1938 their behaviour as to fruiting was studied and the data compiled on the lines detailed above.

Before closing this section of the paper, it is necessary to explain one point. Some may object to the inclusion of only one tree in the investigation after the year 1934. With regard to this, the attention of the reader is called to the importance of the 'build up' of the tree emphasized by R. G. Hatton [1930, 1931] who, after a long series of experiments on the standardization of apple rootstocks, has shown the necessity of producing the rootstocks by vegetative means to reduce errors in the field experiments. To be sure of the 'build-up' of the tree only one tree was selected, in which case there being only one stock and one scion, the element of uncertainty with regard to the material was eliminated. Of course the maximum number of shoots of representative type available on the tree in each category were included in the investigation and wherever possible not less than 100 shoots were selected in each category to start with, although, of course, later on, on account of sub-classification of the shoots according to their behaviour with regard to fruiting, the number in each group was reduced.

The nature of the work does not appear to demand the application of any statistical method to determine significant differences in the results as most of the data accumulated during the period under study relate primarily to the periodicity and cessation of growth of shoots of bearing and non-bearing type. The general behaviour and consistency of the main results shown throughout the investigations is of sufficient significance to justify the discussion of the results without the application of any such method. However, in 1932 and 1933 when the trees under observation were six representing six replicates, the method of analysis of variance advocated by Fisher [1934] was applied on Tables II, IV and VI in the appendix to see whether the results were significant. From each table variances due to different variables were separated and standard error of the mean and significant difference calculated from the variance due to error. Standard errors of the means and significant differences were calculated and shown along with the tables.

III. Presentation of data.

In connexion with the periodicity or seasonal elongation of the shoots and their subsequent behaviour in regard to flowering or non-flowering in the following spring, the terms 'would-be flowering shoots' and 'would-be non-flowering shoots' are frequently used. In order to avoid any misunderstanding, it may be mentioned that 'would-be flowering shoots' would refer to those shoots that flowered in the following spring and 'would-be non-flowering shoots' were those that did not flower in the following spring.

1. PERIODICITY OF EXTENSION GROWTH, 1932

(a) April flush

1. *Actual mean extension growth.*—Data regarding the mean total extension growth in centimetres per shoot in 1932 of April flush shoots that flowered or remained barren in the following year is given in Table I and shown graphically in Fig. 1 (a).

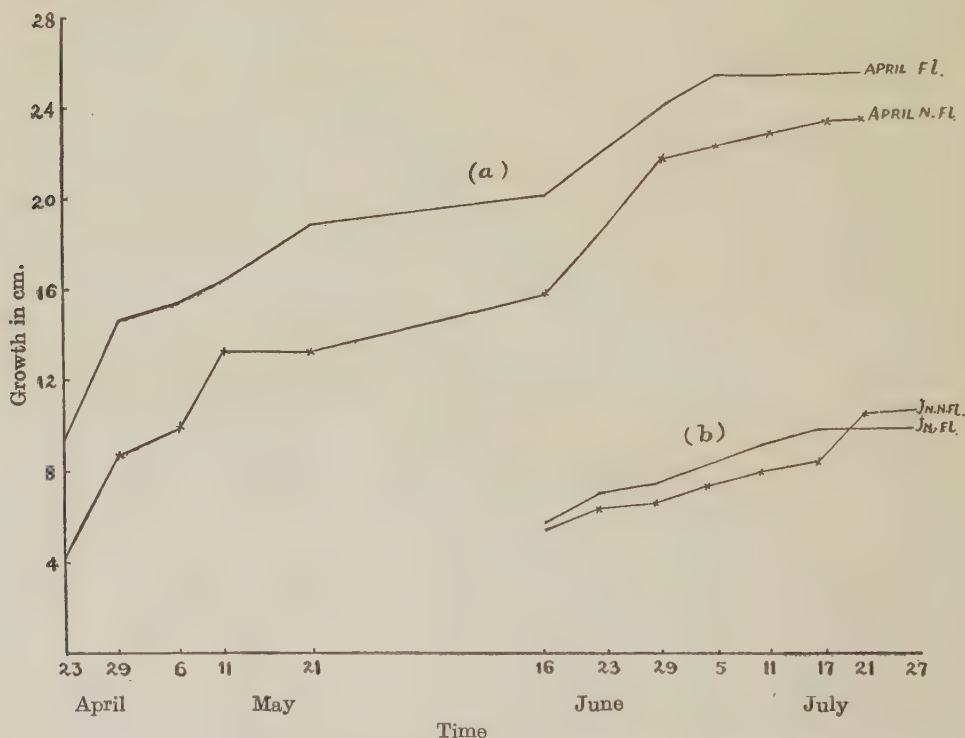


FIG. 1. Mean extension growth in 1932 of 'would-be flowering' and 'would-be non-flowering' shoots of April and June flushes

Fig. (a) 1 shows that during the last week of April the growth rate was high in the case of both 'would-be flowering' and 'would-be non-flowering' shoots after which till the beginning of May the growth slowed down in both the cases. From 6th to 21st May there was a gradual increase in the growth of 'would-be flowering' shoots, whereas in 'would-be non-flowering' ones the growth was rapid from 6th to 11th May, after which it stopped altogether for about ten days. From 21st May to 16th June there was a gradual increase in both the shoots after which another stimulus was observed till the end of June in both the 'would-be flowering' and 'would-be non-flowering' shoots. From the beginning of July till the end of the growing season, growth slowed down in the 'would-be non-flowering' shoots whereas in the others it stopped altogether.

2. *Calculated growth on percentage basis.*—Data in Table I were re-calculated on the basis of percentages on the final length of the shoots at the end of the growing season and shown in Table II.

Table II shows that from the beginning of the growing season till the middle of June, the percentage amount of growth produced by the shoots that flowered subsequently was significantly higher than those that remained barren. After this till the end of the growing season there was no significant difference between the percentage growth of shoots of both the categories, although the figures in the case of 'would-be flowering' shoots remained comparatively high.

(b) *June flush*

1. *Actual mean extension growth.*—Data regarding the mean total extension growth in centimetres per shoot in 1932 of June flush shoots that flowered or remained barren in the following year is presented in Table III and shown graphically in Fig. 1 (b).

Fig. 1. (b) shows that out of the shoots of June flush those that subsequently flowered or remained barren there was practically no difference in the rate of their extension growth from the beginning of the growing season till the middle of July, after which the growth ceased altogether in the case of 'would-be flowering' shoots whereas the 'would-be non-flowering' shoots grew rapidly for a week and slowed down later on at the end of the growing season.

2. *Calculated growth.*—Data from Table III were re-calculated in percentages on the final length of the shoots and presented in Table IV.

Table IV shows that, from the beginning of the time the growth started till the middle of July, the percentage amount of growth in the 'would-be flowering' shoots was significantly higher than the 'would-be non-flowering' ones. After the middle of July the percentage growth of both the types of shoots was practically at the same level.

2. PERIODICITY OF EXTENSION GROWTH, 1933

(a) *Non-bearing shoots of April and June flushes*

1. *Actual mean extension growth.*—Data regarding the mean total extension growth in centimetres per shoot in 1933 of shoots that flowered or remained vegetative in the following year (1934) is given in Table V and shown graphically in Fig. 2.

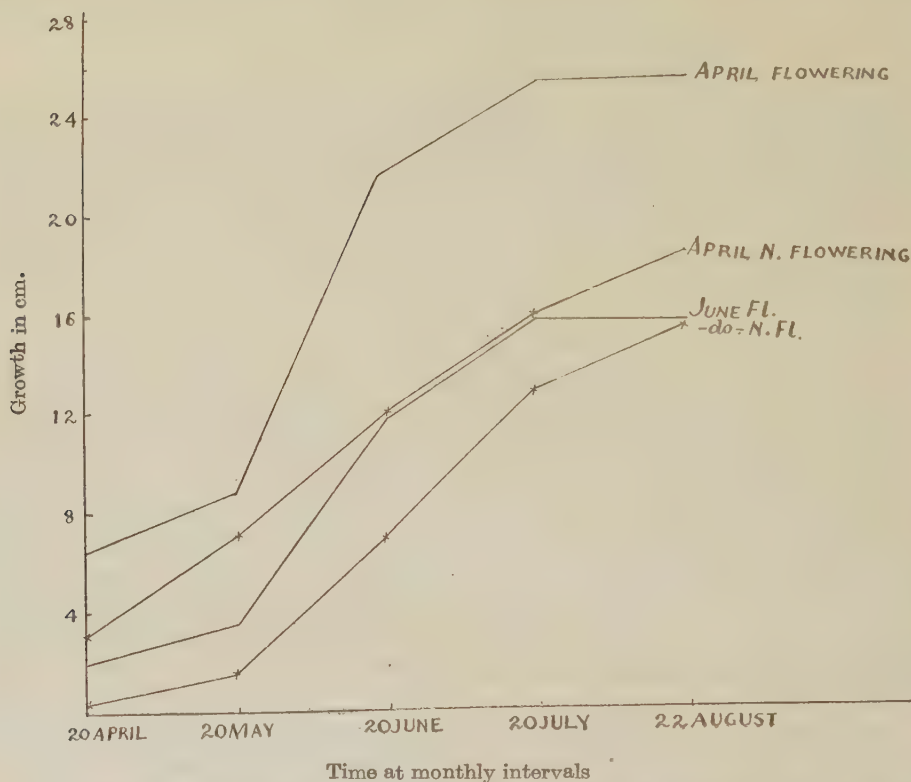


FIG. 2. Mean extension growth in 1933 of 'would-be flowering' and 'would-be non-flowering' shoots of April and June flush shoots non-bearing in 1933

In Fig. 2, while comparing the growth curves of the April flush it is evident that greater amount of growth was produced by shoots that flowered in the subsequent year than those that remained barren from the 3rd week of May to the 3rd week of June after which period both the types of shoots grew practically at the same rate for a month. Towards the end of the growing season for about a month the shoots that flowered in the following spring had stopped growing, whereas during this period the others continued growth at a rapid rate.

With regard to the June flush shoots, both kinds of shoots grew practically at the same rate during the first month of their growing season. During the 2nd month, however, the 'would-be flowering' shoots grew at a more rapid rate than the 'would-be non-flowering' ones. During the next month the 'would-be non-flowering' shoots grew more than the others and during the last month of the growing season the 'would-be flowering' shoots stopped growing altogether while the 'would-be non-flowering' ones continued growth.

2. *Calculated growth.*—Data from Table V were re-calculated in percentages on the final length of shoots and presented in Table VI.

Table VI shows that the percentage amount of growth produced by the 'would-be flowering' shoots of April flush was more than the 'would-be non-flowering' ones throughout the growing season, though, during the first month of the growth, the difference was not significant. In the case of the June flush the 'would-be flowering' shoots produced significantly more growth than the 'would-be non-flowering' ones throughout the growing season.

If comparison is made between 'would-be flowering' shoots of the April and June flushes it is evident that growth produced by the April flush was significantly more than the June flush till the last week of June but during the end of the next month the shoots in both the flushes were at the same level. The behaviour of 'would-be non-flowering' shoots of both the flushes was also the same.

(b) *Bearing shoots of April and June flushes*

1. *Actual mean extension growth.*—As is clear from Table VII, out of 50 shoots of the April flush and 39 of the June flush, all of which were bearing fruit, only 15 in the former and two in the latter made extension growth during the same year, and out of these only two in the former case and none in the latter flowered in the following spring (1934). The data regarding the mean total extension growth in 1933 of bearing shoots that flowered or remained vegetative in the following year is given in Table VII and shown graphically in Fig. 3.

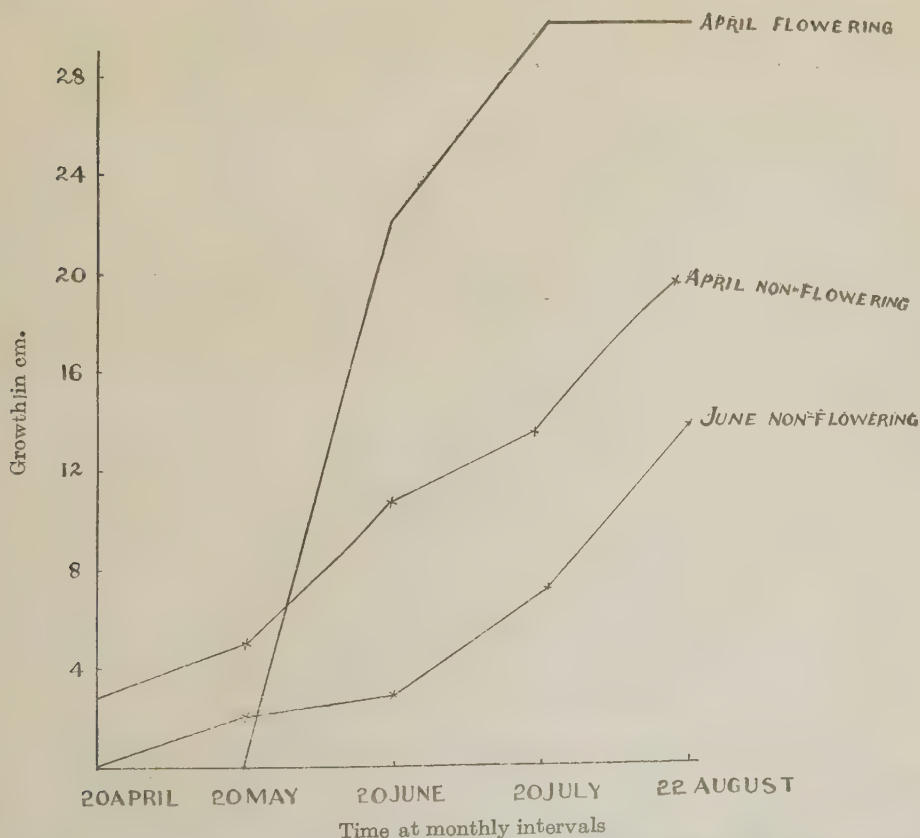


FIG. 3. Mean extension growth in 1933 of 'would-be flowering' and 'would-be non-flowering' shoots of April and June flushes bearing in 1933

Fig. 3 shows that the bearing shoots of the April flush, which also flowered in the following spring (1934), made very rapid growth from May to June (1933) and for another month continued growth at a slower rate and ceased growing altogether towards the end of July. On the other hand those bearing shoots of the April flush which did not flower in the subsequent year (1934) continued growth till late in the season of 1933 with no indication of rapid growth between 20th May and 20th June.

No shoot of the June flush flowered and consequently no growth curve for these is plotted in the figure. The 'would-be non-flowering' shoots of this flush if compared with 'would-be non-flowering' shoots of the April flush show that their growth curves are similar, especially during the later part of the growing season.

2. *Calculated growth.*—From Table VII the mean growth in percentages on the final length of shoots was calculated and is shown in Table VIII.

In Table VIII no significant differences were calculated owing to the paucity of shoots under each category, though it is quite evident that during the month of June and July the growth of 'would-be flowering' shoots of the April flush was more than the 'would-be non-flowering' ones.

3. GROWTH PERFORMANCE AND FLOWERING RECORDS OF SHOOTS FROM 1933-34

(a) *Actual growth and flowering record of shoots selected in 1932*

Data regarding the growth and flowering record, from 1932-34 of April and June flush shoots selected in 1932 are presented in Table IX.

Columns 1 and 2 of Table IX give the name of flush and number of shoots selected in each flush respectively. Column 3 gives the number of shoots that flowered or remained barren out of the shoots in column 2. Column 4 gives the number of shoots that grew out of those in the previous column. Column 5 gives the number of shoots that flowered or remained vegetative out of shoots in the previous column. This table shows two things of great interest, firstly that the shoots that flowered were out of those shoots that made extension growth in the preceding year and secondly the flowering shoots during their year of bearing grew in less number as compared to non-flowering ones. The latter point is brought out more clearly in Table X.

(b) *Percentage number of shoots flowering and growing*

Data from Table IX are re-calculated on percentage number of shoots growing and bearing in each year and presented in Table X.

In column 2 of Table X the shoots of each flush selected are assumed as 100. In the 3rd column the percentage of shoots flowering and non-flowering out of column 2 is given. In column 4 percentage of shoots growing out of the previous column is presented, while in the last column the percentages given are calculated on the number of shoots in column 3.

Table X shows that out of 100 shoots growing in 1932 in each flush, 37.3 flowered in the case of the April flush, and 32.5 in the June flush in 1933, showing a slight increase in the number of flowering shoots in the April flush. Out of the shoots that flowered in 1933, a much smaller number made extension growth as compared with those that did not flower, showing an inverse correlation between growth and productivity during the same year. Again if the

flushes are compared between themselves, more shoots grew in the case of the April flush. In 1934 greater number of shoots flowered out of those which did not flower in the previous year. And conversely a smaller number of shoots flowered out of those which flowered in the previous year in the case of the April flush and none at all in the case of the June flush, thus showing a tendency of alternate bearing on the same shoots.

In 1934 also the April flush continued to be more important than the June flush with respect to productivity.

4. PERIODICITY OF EXTENSION GROWTH, 1935

(a) *Shoots of different flushes selected in 1935 and allowed to grow without imposing any other treatment on them*

The mean total extension growth in centimetres per shoot of different flushes is given in Table XI and shown graphically in Fig. 4. The calculated mean growth per shoot in percentages on the final length of the shoot is also given in this table.

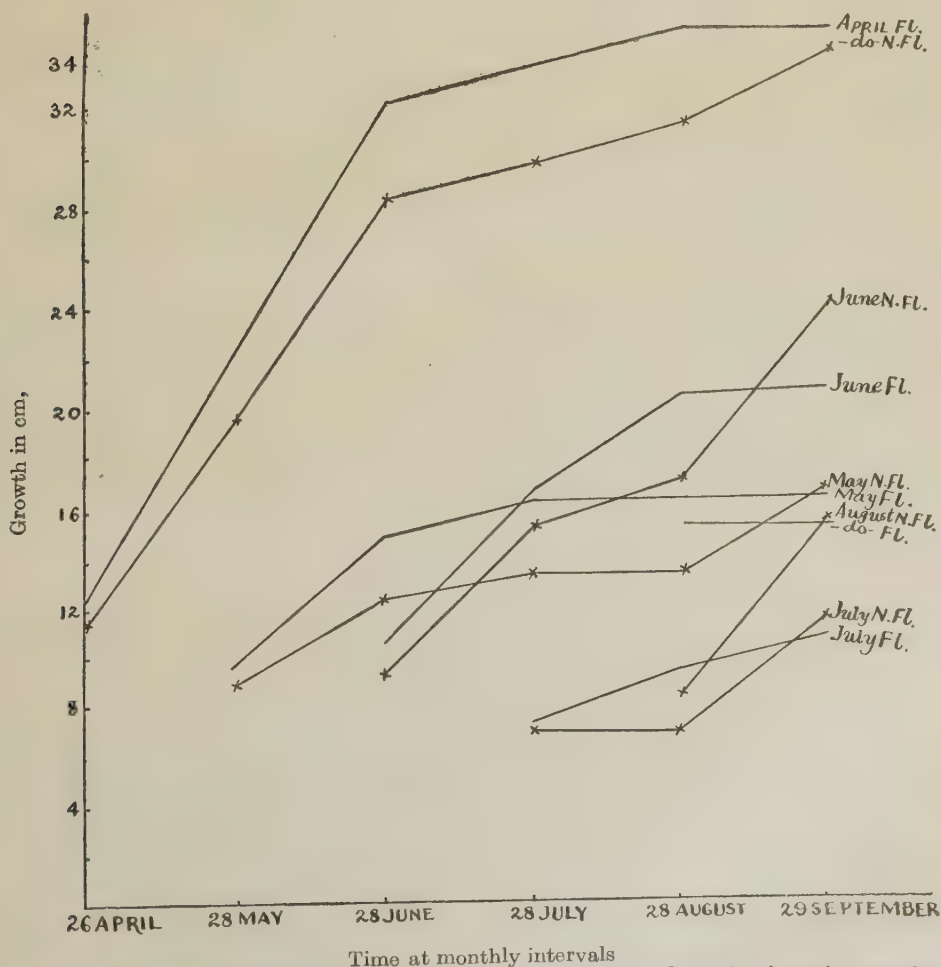


FIG. 4. Mean extension growth in 1935 of 'would-be flowering' and 'would-be non-flowering' shoots

April flush.—In shoots that flowered in the following year the rate of extension growth during May, June and July was more than the 'would-be non-flowering' ones, after which for a month the latter shoots grew at a slightly more rapid rate than the former ones. During the last month of the growing season the 'would-be flowering' shoots almost ceased growing, whereas the others continued growth at a rapid rate.

May flush.—The 'would-be flowering' and 'would-be non-flowering' shoots of this flush behaved in exactly the same way as those of the April flush. During the earlier part of the growing season, the growth rate of 'would-be flowering' shoots was more than the 'would-be non-flowering' ones, whereas during the last month it was quite the reverse.

June flush.—The behaviour of shoots in both the categories was in conformity with those of other flushes already mentioned above.

July flush.—The 'would-be flowering' shoots grew at a quicker rate than the 'would-be non-flowering' ones till August, after which the growth in the former slowed down considerably, whereas the latter grew during the first month, stopped altogether for the next and started to grow at a rapid rate during the last month of the growing season.

August flush.—The 'would-be flowering' shoots grew only during the month of August, and stopped extension growth altogether in September, whereas the non-flowering shoots went on growing till the end of the growing season.

From the above data on the shoots of all the flushes it is borne out clearly that the shoots that flowered in subsequent year made extension growth at rapid rate early in the season and stopped growing about a month earlier as compared to the shoots which remained barren in the following spring.

The calculated extension growth in percentages on the final length of the shoots in Table XI shows that invariably in all flushes the percentage of growth produced by the shoots that flowered in subsequent year was much more than the others throughout the early part and major portion of the growing season.

(b) *Deblossomed shoots*

The mean total extension growth, actual and calculated in percentages, of shoots that were deblossomed in early spring 1935 is given in Table XII. The mean total extension growth is shown graphically in Fig. 5.

In Fig. 5 it is quite interesting to note that extension growth in both the categories of shoots (i.e., those flowering or not flowering in the following year) did not take place during April and May. In June both the types of shoots started to grow but the 'would-be flowering' ones evidently grew earlier and at a much quicker rate than the others. By the end of July the 'would-be flowering' shoots had made slightly greater growth than the 'would-be non-flowering' ones. In the following two months the 'would-be flowering' shoots (i.e. flowering in the subsequent spring 1936) made very little growth, while the others that remained barren in the subsequent spring made

tremendous growth during the month. Table XII shows that out of the total extension growth made by shoots of both categories the 'would-be flowering' shoots made 97.4 per cent against only 54.5 per cent in the case of 'would-be non-flowering' ones by the end of August.

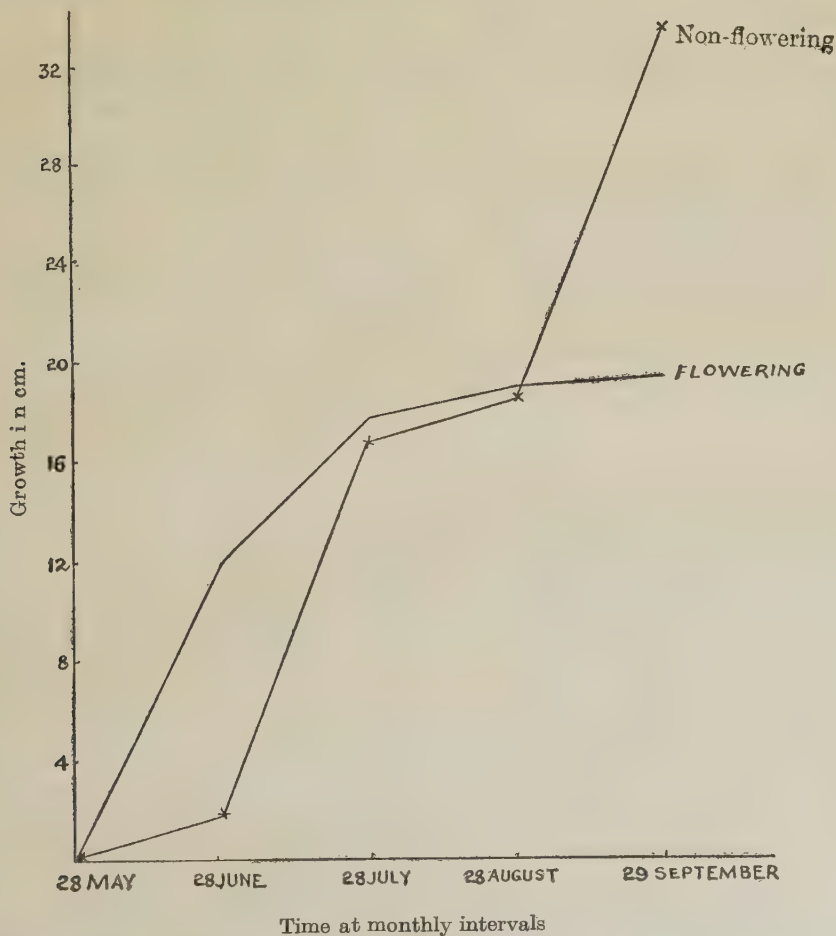


FIG. 5. Mean extension growth in 1935 of 'would-be flowering' and 'would-be non-flowering' shoots deblossomed in 1935

5. GROWTH PERFORMANCE AND FLOWERING RECORDS OF SHOOTS FROM 1935-38

(a) *Shoots of different flushes selected in 1935 and allowed to grow without imposing any other treatment on them*

1. Actual data regarding the growth and flowering records from 1935 to 1938 of different flushes selected in 1935 are presented in Table XIII.

Table XIII is self-explanatory excepting columns 6 and 7 which need explanation. In column 6, (a) shows the number of shoots growing out of flowering shoots in the previous column ; (b) shows the number of shoots growing out of the non-flowering shoots in the previous column ; and (c) shows the number of shoots growing out of shoots (in column 4) which did not grow in 1936. Column 7 shows the number of growths produced on the total number of growing shoots in the previous column. It is evident from the table that out of the shoots that flowered in spring, smaller number made extension growth in the subsequent year as compared to the non-flowering ones. Also the flowering shoots in the subsequent year fruited in far less number than the others.

Table XIV, which is prepared from Table XIII, clearly indicates this behaviour of the shoots.

TABLE XIV

Percentages of shoots growing in 1936 and bearing in 1937 out of flowering and non-flowering shoots under each flush in 1936

Name of flush	No. of shoots flowering and non-flowering in 1936		Percentage No. of shoots growing in 1936	Percentage No. of shoots flowering in 1937	Remarks
April	(a) Flowering	156	31.4	1.9	} Shoots largely in shade
	(b) Non-flowering	44	79.5	13.6	
May	(a) Flowering	83	4.8	0.0	
	(b) Non-flowering	17	5.8	0.0	
June	(a) Flowering	90	17.7	1.1	
	(b) Non-flowering	10	90.0	10.0	
July	(a) Flowering	7	..	..	
	(b) Non-flowering	3	100.0	66.0	
August	(a) Flowering	5	..	..	
	(b) Non-flowering	5	60.0	20.0	

Out of the shoots in each flush that flowered in 1936 very few made extension growth during the same year, and also flowered in less number in the following year as compared to the non-flowering shoots, thus showing firstly the tendency of individual shoots to bear in alternate years and secondly that growth in the preceding year predetermines the fruitfulness in the subsequent year or in other words there is a direct relationship between number of shoots growing in the preceding year and the number of shoots flowering in the following year.

2. *Calculated data in percentages on the original number of shoots.*—In order to elucidate the above observations more clearly the data of Table XIII are calculated in percentages on the original number of shoots selected under each flush in 1935 and presented in Table XV.

The table shows firstly that out of the shoots of each flush of 1935 the percentage of flowering shoots was very much higher in 1936 than in 1937 and it again went up in 1938. Secondly the relation of number of shoots growing in the preceding year and the number of shoots flowering in the following year was again established by the data in Table XV. Thirdly there was an antagonism between the number of shoots growing and number of shoots bearing during the same season, i.e. vegetative growth was at the expense of fruitfulness and *vice versa*.

If the mean of all the flushes is taken as shown in Table XV, it would show the behaviour of the tree as a whole as the representative shoots from each flush were selected on the tree. The behaviour of the tree as a whole with regard to growth and productivity is the same as mentioned above for each flush.

The relative importance of different flushes with respect to productivity is also shown in column 3 of Table XV, where it is evident that three flushes initiated earlier were more important than the other two initiated later.

(b) *Deblossomed shoots*

It has been clearly demonstrated that (a) shoots bearing fruits seldom make extension growth during the season and seldom bear fruit next year and (b) shoots making extension growth largely bear crop next season provided growth ceases fairly early in the season. It would be interesting to note how the shoots, actually in flowering would behave with regard to extension growth during the season and fruiting during the next season in case they are deblossomed.

Table XVI shows that shoots that were deblossomed in 1935 grew again in the same year and out of the 27 shoots no less than 20 flowered in the following year. The shoots that flowered in 1936 did not grow again during the same year, while of the others which did not flower in 1936 all excepting one grew. In 1937 no shoot flowered out of those flowering in 1936 and two flowered out of those that did not flower in the previous year.

The data from Table XVI is calculated in percentages on the original number of shoots deblossomed in 1935 and presented in Table XVII which shows that: firstly deblossoming the shoots induced them to grow again during the same year and to flower in the subsequent years; secondly the percentage of flowering shoots in 1936 was more than in 1937, and in 1938 again the percentage of flowering shoots went high, thus showing the tendency of individual shoots to bear in alternate years; thirdly there was a positive correlation between growth in the preceding year and productivity in the following year; and fourthly there was an antagonism between the number of

flowering and growing shoots during the same year and all this is in conformity with the results obtained in the case of normal shoots not deblossomed.

6. PERIODICITY OF EXTENSION GROWTH, 1937

The mean total extension growth in centimetres and calculated growth on percentage basis per shoot of various flushes selected in 1937 are given in Table XVIII and shown graphically in Fig. 6.

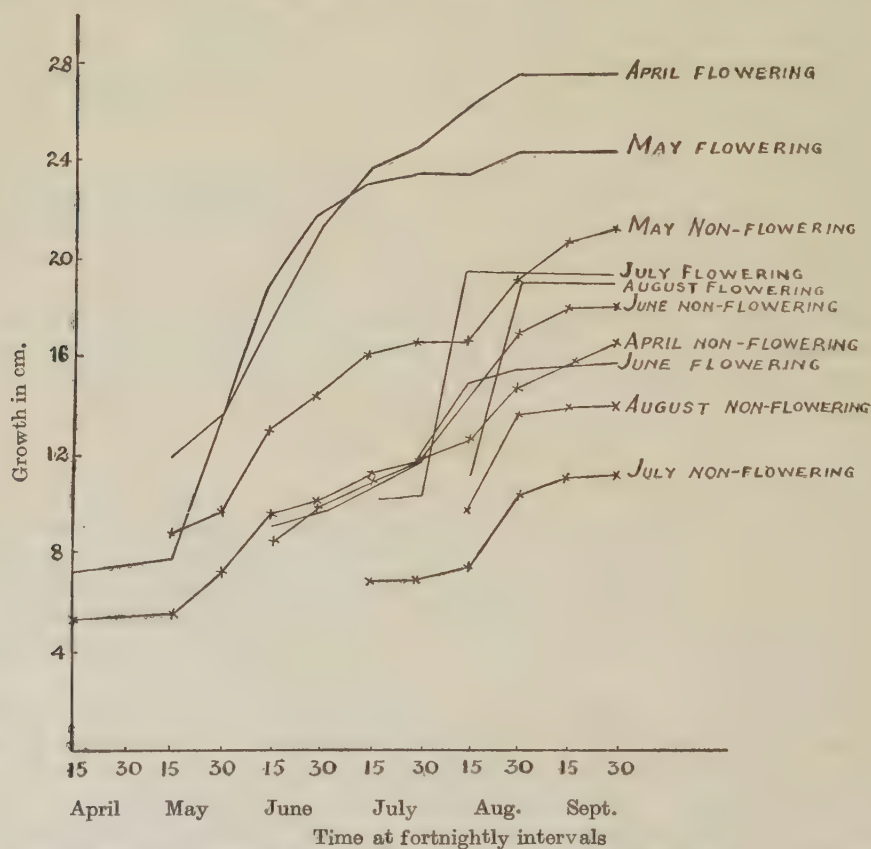


FIG. 6. Mean extension growth in 1937 of 'would-be flowering' and 'would-be non-flowering' shoots

April flush.—The rate of growth of 'would-be flowering' and 'would-be non-flowering' shoots from April 15th to May 15th was the same after which period till 15th July the growth was progressing at a rapid rate in the case of former shoots, whereas in the latter ones the growth during this period was slow. From 15th July to 30th August the growth rate was practically the same in both the categories of shoots after which the 'would-be flowering' shoots stopped altogether while the others went on growing till the end of September.

May flush.—From 15th May to 30th June the growth rate in case of 'would be flowering' shoots was slightly more than the 'would-be non-flowering' ones after which till 15th August both the types of shoots were growing at the same rate. After 15th August the 'would-be non-flowering' shoots grew at a rapid rate till the end of September while 'would-be flowering' shoots stopped growing as early as the end of August.

June flush.—The growth of both the categories of shoots was at the same rate till 30th July after which for a fortnight the 'would-be flowering' shoots were growing comparatively rapidly. From 15th to 30th August the 'would-be non-flowering' shoots grew at a rapid rate, whereas the 'would-be flowering' ones during this period slowed down considerably and ceased growth by 30th August. The 'would-be non-flowering' shoots went on growing till the middle of September.

July flush.—Both the types of shoots stopped growing from 15th to 30th July after which for a fortnight the 'would-be flowering' shoots grew at a more rapid rate than the 'would-be non-flowering' ones. On 15th August the growth of 'would-be flowering' shoots ceased, whereas the 'would-be non-flowering' ones went on growing till 15th September, after which the growth slowed down and finally stopped at the end of September.

August flush.—The growth of 'would-be flowering' shoots was more than the 'would-be non-flowering' ones from 15th to 30th August. After this the former ceased growing altogether, whereas in the latter the growth slowed down.

From the above it is evident that the 'would-be flowering' shoots (i.e. those that flowered in the subsequent spring) in every flush produced more growth earlier in the growing season and stopped earlier, whereas the 'would-be non-flowering' shoots produced more growth during the latter part of the growing season and continued to grow till late in the season. All the shoots that flowered in subsequent year stopped growth by the end of August, while the others continued to grow till the end of September.

Table XVIII, besides showing the actual extension growth at fortnightly intervals, also shows the growth in terms of percentages which elucidates even more clearly the points referred to above.

7. RELATIVE IMPORTANCE OF VARIOUS FLUSHES WITH RESPECT TO PRODUCTIVITY

From column 2 of Table XVIII the percentage number of shoots that flowered in each flush is calculated and set out below.

Name of flush	April	May	June	July	August
Percentage number of shoots flowering . .	36.7	29.4	19.8	11.0	7.0

The table shows that the shoots initiated earlier in the growing season came into flower in greater number than those which started to grow late, emphasizing that the earlier flushes are more important from the point of view of productivity.

IV. Discussion

The seasonal elongation of shoots, as observed over a number of years on a considerable number of shoots growing on several or individual trees, revealed that the flowering and non-flowering shoots (i.e. the shoots that in the subsequent spring were to flower or remain barren) exhibited in the previous season a marked difference in their growth periodicity. The flowering shoots in the preceding year grew at a much rapid rate and put on relatively more growth during the early part of the growing season as well as ceased growing about a month earlier than those which did not flower. The non-flowering shoots during the preceding year grew at a lower rate in the beginning and went on growing till late in the season. The association of more amount of growth during the early part of the growing season and cessation of extension growth earlier to fruit bud formation is conclusively established in shoots of the Langra mango under Lyallpur conditions. The reason for this behaviour of the shoots can be sought in their period of leaf activity and maturation of their wood. Khan [1938], working on apples, has shown the similarity of curves for total leaf area and total shoot growth. This shows that periodicity of extension growth and seasonal development of leaf area are associated, and it is reasonable to believe that the same relation also holds good in the case of the fruit under study. Consequently leaf area in the case of shoots developing and stopping earlier remained active over a greater period in the growing season as compared to other shoots, and was thus responsible for fruit bud differentiation. Hartless [1913] has mentioned that hard, ripe wood in mango is very essential for fruiting, and flowering shoots of mango are usually produced in late spring and summer. He mentions that he saw a very good crop of mango following a monsoon that closed completely fairly early in September and that a prolonged monsoon was inimical to a good mango season the following year. In fact research on this phase of the problem on apples and other fruits has also shown that any treatment, whether rootstock, pruning, ringing or any cultural practice that induce this type of growth are conducive to fruit bud formation. It has been shown by Swarbrick [1927] that under certain conditions ringing is a sure way of bringing about flower bud formation in over-vegetative trees. Lees [1926] has pointed out that in England dry summers are more conducive to flower bud formation than the wet ones. Again certain vegetative rootstocks have also been shown to bring about precocity in the scions worked upon them [Hatton, 1920, 1925]. It is well known also that fruit trees under sod or some form of cover crops are more prolific of fruit bud formation than those under clean cultivation provided nitrogen is not a limiting factor. All the above conditions have a common influence on tree growth in that they retard the vegetative growth and induce its cessation relatively earlier in the season.

The second point to be discussed is the growth performance and flowering records of shoots from year to year. It was found in this connection that in mature trees there was an antagonism between productivity and growth on the same shoots during the same growing season. The shoots bearing fruit either did not grow or grew in very small number during the same growing season, whereas non-fruiting shoots grew in greater number. Secondly the shoots that flowered in one season either did not flower at all or flowered in very small number in the following year, showing a tendency to bear biennially. Thirdly only those shoots flowered which grew and stopped growth earlier in the preceding year. The shoots that did not grow did not flower in the following year, showing that flowering in Langra mangoes took place only on one year old growths and consequently there was a direct relationship between the number of shoots growing in a season and the number of shoots flowering in the subsequent year, provided of course the number of growing shoots produced desirable type of extension growth required for fruit bud formation. From the above information it is evident that lack of fruiting on the shoots of Langra mangoes in any particular year is brought about through lack or absence of the desirable type of extension growth in the preceding year. This, combined with the antagonism of fruiting to vegetative growth, brings about biennial bearing. This would explain partly why young mango trees comparatively bear regularly every year, since along with fruiting, adequate amount of growth is also being produced. If by some means a balance between growth and flowering is maintained every year, it should be possible to secure a reasonable crop year after year. It would be desirable to mention here how throughout the province there is very little or no mango crop in one year and plenty in another which should not happen in the normal course on account of the fact that all mango plantations are not of the same age. This phenomenon of biennial bearing in mango throughout the mango-growing areas is brought about by external factors, like frost or pests and diseases, which annihilate either the potential fruit buds or crop throughout and disturb the equilibrium of the trees. During the year if the crop is damaged all the energy of the trees is expended in the production of vegetative growth and during the next year if there is no external calamity the trees blossom profusely and fruit in abundance with no vegetative growth to provide for the crop during the next year. Once this happens the trees tend to bear biennially unless of course this habit is again changed by the external factors mentioned above. It stands to reason that in a year of heavy fruiting, any cultural treatment tending to encourage extension growth of shoots should bring about fruiting in the subsequent year also and thus break the biennial bearing habit of the tree.

It has been shown that the shoots that ceased growth earlier became productive irrespective of their age, though, of course the number of such shoots was greater in flushes initiated earlier. April, May and June flushes were found to be more important than July and August flushes from the point of view of fruitfulness. Excepting one year the order of importance even in the three earlier flushes was according to the time these were initiated,

i.e. April flush was more important than the June flush and June flush in turn was more important than July flush. If comparison is made between July and August flushes the former was more important than the latter. This information throws some light on the importance of early growth initiation. And to get a reasonable quantity of crop in mangoes under Lyallpur conditions it is very essential that the growth initiation should take place fairly early in the preceding season. In the light of this it seems desirable to modify the cultural practices in a way so as to bring about maximum growth fairly early in the season.

Deblossoming the shoots early in the spring resulted in inducing the deblossomed shoots to grow in the same season and behave like other shoots not bearing fruit, and about 70 per cent of these shoots flowered and fruited again in the subsequent year. This response of mango to deblossoming seems to be of vital importance in regulating the crop every year, since by adopting this practice it is shown to be possible to induce vegetative growth in the tree during the same year and bring about fruiting in the following year. Overbearing during one year brings about biennial bearing in the mature mango trees, and by deblossoming this habit can be averted and the trees brought into bearing annually. These results are supported by the evidences of other workers on other fruits. Aldrich [1931] has shown that thinned trees set more blossom in the subsequent year than the unthinned ones. Aldrich and Fletcher [1932] have proved that heavy fruit thinning within six weeks of blossoming dates is apparently effective in increasing the fruit bud formation for the following year. McCormick and others [1933] have pointed out that pre-thinning (a term used to denote the procedure of removing blossom clusters at or about blooming time) would correct biennial bearing in apples. Potter [1936] has shown that biennial bearing is due to an early drain on the tree caused by the many fruit developing prior to June drop and early thinning may be expected to increase the amount of bloom in the succeeding year. He has shown that on an average 25 per cent of the spurs on the trees thinned earlier in the season produced blossom again in the following year.

V. Summary and conclusion

1. The paper deals with the investigations carried out at Lyallpur from 1932 to 1938 on the relation of growth to bearing in mangoes.

2. Six uniform grafted Langra mango trees of the same age growing on seedling rootstocks and under uniform cultural and other treatments were included in the investigation in 1932 and kept under observation up to the spring of 1934. In 1935 only one tree was included in the project to eliminate the element of uncertainty with respect to the 'build up' of the tree and this tree was kept under observation till the spring of 1938. In 1937 another tree was included in the experiment and kept under study till 1938.

3. From the above trees, flushes initiated during different months of the growing seasons on the last year's growths were selected and designated according to the month in which they started to grow.

4. Shoots of different flushes were labelled and seasonal elongation of each shoot was recorded after suitable intervals of one week, two weeks and a month in different years till the extension growth stopped altogether. In the following year the behaviour of each individual shoot was noted with respect to flowering or otherwise. They were grouped into flowering and non-flowering shoots and the means of seasonal elongation of growth of these shoots in the previous year computed separately for both types of shoots. In the text of this paper, while discussing the behaviour of these shoots in regard to their growth periodicity prior to flowering, the terms 'would-be flowering' shoots and 'would-be non-flowering' shoots have been used for these shoots.

5. In addition to the study of seasonal elongation of shoots and its bearing on fruiting in the following year, observations on these shoots were continued for a couple of years in regard to their growth and flowering performance.

6. Flowering shoots were deblossomed and their behaviour in regard to seasonal elongation during the year of deblossoming as well as flowering or otherwise in the following year was studied and this was continued for four years.

7. The data was examined statistically whenever the material warranted such examination.

8. 'Would-be flowering' and 'would-be non-flowering' shoots exhibited a marked difference in their growth periodicity during the year preceding flowering. Shoots that flowered in the subsequent year made most of the extension growth early in the season and ceased growing about a month earlier as compared to the shoots that did not flower in the following spring. This was consistently observed over a period of four years on about 1,300 shoots of April, May, June, July and August flushes.

9. An antagonism between productivity and growth on the same shoots during the growing season was established, i.e. fruiting and vegetative growth were always at the expense of each other.

10. There was a direct relationship between the number of shoots growing in one season and the number of shoots flowering in the subsequent spring.

11. The shoots that flowered in one season either did not flower or flowered in very small number in the following year, thus indicating a tendency of alternate bearing on individual shoots. The causes of 'on' or 'off' years in mangoes throughout the mango-growing tracts are also discussed.

12. The fruit-bud initiation took place only on one season old shoots.

13. The flushes initiated early were more important than those initiated late in the season with respect to productivity in the following year.

14. Deblossoming early in the season resulted in inducing the shoots to grow in the same season and bear in the next. They behaved exactly in the same way as shoots that did not flower,

VI. Acknowledgment

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Appendix

TABLE I

Mean total extension growth in 1932 of 'would-be flowering' and 'would-be non-flowering' shoots of April flush

No. of shoots under observation	Extension growth in 1932 in centimetres											Behaviour in 1933	
	23/4	29/4	6/5	11/5	21/5	16/6	23/6	29/6	5/7	11/7	17/7		21/7
50	9.5	15.0	15.8	16.8	19.3	20.4	22.5	24.4	25.7	25.7	25.7	25.7	Flowering
84	4.3	8.9	10.1	13.7	13.7	16.0	19.2	22.1	22.5	23.0	23.5	23.6	Non-flowering

N.B.—Altogether 134 shoots had been selected in April 1932. Out of these 50 shoots flowered in the following spring (i.e., 1933) and 84 did not flower. Their behaviour with respect to their growth during the year preceding flowering is given above.

TABLE II

Data of Table I is represented on percentage basis (S. E. of the mean 2.35, sig. diff. 7.46)

No. of shoots under observation	Percentage extension growth in 1932											Behaviour in 1933	
	23/4	29/4	6/5	11/5	21/5	16/6	23/6	29/6	5/7	11/7	17/7		21/7
50	36.9	58.4	61.5	65.4	75.1	79.4	87.6	94.9	100.0	100.0	100.0	100.0	Flowering
84	18.2	37.7	42.8	58.0	58.0	67.7	81.3	93.6	95.3	97.4	99.5	100.0	Non-flowering

TABLE III

Mean total extension growth in 1932 of 'would-be flowering' and 'would-be non-flowering' shoots of June flush

No. of shoots under observation	Extension growth in 1932 in centimetres							Behaviour in 1933
	15/6	21/6	27/6	3/7	9/7	15/7	21/7	27/7
39	5.8	7.1	7.5	8.3	9.2	9.9	9.9	9.9
81	5.5	6.5	6.7	7.5	8.1	8.5	10.6	10.7

NOTE.—Altogether 120 shoots had been selected in June 1932. Out of these 39 shoots flowered in the following spring (1933) and 81 did not flower. Their behaviour with respect to their growth during the year preceding flowering is given above.

TABLE IV

Data of Table III represented on percentage basis (S. E. of the mean 2.12, sig. diff. 6.64)

No. of shoots under observation	Percentage extension growth in 1932							Behaviour in 1933
	15/6	21/6	27/6	3/7	9/7	15/7	21/7	27/7
39	58.6	71.7	75.8	83.9	92.9	100.0	100.0	100.0
81	51.4	60.7	62.6	70.0	75.7	79.4	99.0	100.0

TABLE V
Mean total extension growth in 1933 of 'would-be flowering' and 'would-be non-flowering' shoots of April and June flush shoots non-bearing in 1933

Name of flush selected in 1932	No. of shoots non-bearing in 1933	No. of shoots that made extension growth in 1933	Behaviour of shoots in 1934	Extension growth in 1933 in cm.				
				20/4	20/5	20/6	20/7	22/8
April	84 (vide Table I)	56	Flowering 40 Non-flowering 16	6.4	8.8	21.5	25.4	25.4
June	81 (vide Table III)	35	Flowering 22 Non-flowering 13	3.1 1.9 0.3	7.0 3.5 1.5	12.1 11.6 6.9	16.0 15.7 12.9	18.5 15.7 15.6

TABLE VI
Data of Table V represented on percentage basis (S. E. of the mean 1.35, sig. diff. 4.25)

Name of flush selected in 1932	No. of shoots non-bearing in 1933	No. of shoots that made extension growth in 1933	Behaviour of shoots in 1934	Percentage extension growth in 1933				
				20/4	20/5	20/6	20/7	22/8
April	84 (vide Table I)	56	Flowering 40 Non-flowering 16	25.2	34.7	84.7	100.0	100.0
June	81 (vide Table III)	35	Flowering 22 Non-flowering 13	16.7	37.8	65.4	86.5	100.0
				12.1	22.3	74.0	100.0	100.0
				1.9	9.6	44.2	82.7	100.0

TABLE VII

Mean total extension growth in 1933 of 'would-be flowering' and 'would-be non-flowering' shoots of April and June flush shoots bearing in 1933

Name of flush selected in 1932	No. of shoots bearing in 1933	No. of shoots that made extension growth in 1933	Behaviour of shoots in 1934	Extension growth in 1933 in cm.				
				20/4	20/5	20/6	20/7	22/8
April	50 (<i>vide</i> Table I)	15	Flowering 2	..	..	22.3	30.3	30.3
			Non-flowering 13	2.8	4.9	10.6	12.9	19.0
June	39	2	Flowering ..	..	..	..	..	..
	(<i>vide</i> Table III)		Non-flowering 2	..	2.0	2.7	7.0	14.0

TABLE VIII

Data of Table VII represented on percentage basis

Name of flush selected in 1932	No. of shoots bearing in 1933	No. of shoots that grew in 1933	Behaviour of shoots in 1934	Percentage extension growth in 1933				
				20/4	20/5	20/6	20/7	22/8
April	50	15	Flowering 2	..	..	73.6	100.0	100.0
			Non-flowering 13	14.7	25.7	55.8	67.8	100.0
June	39	2	Flowering ..	..	..	..	..	..
			Non-flowering 2	..	14.3	19.3	50.0	100.0

TABLE IX
Growth performance and flowering record from 1932 to 1934 of April and June flush shoots selected in 1932

Name of flush	No. of shoots selected and growing in 1932	No. of shoots flowering in spring 1933	No. of shoots growing in 1933	No. of shoots flowering in spring 1934
April	134	Flowering	50	{ Flowering 2 Non-flowering 13
		Non-flowering	84	{ Flowering 40 Non-flowering 16
June	120	Flowering	39	{ Flowering Nil Non-flowering 2
		Non-flowering	81	{ Flowering 22 Non-flowering 13

TABLE X
Growth performance and flowering record from 1932 to 1934 of April and June flush shoots (selected in 1932) expressed in percentages

Name of flush	Percentage of growing shoots selected in 1932	Percentage of flowering and non-flowering shoots in 1933 (a) Flowering (b) Non-flowering	Percentage of shoots growing in 1933 out of the shoots in the previous column	Percentage flowering shoots in 1934 out of the shoots in column 3
April	100.0	(a) 37.3 (b) 62.7	30.0 66.0	4.0 47.6
June	100.0	(a) 32.5 (b) 67.5	5.1 43.2	0.0 27.1

TABLE XI

Mean total extension growth (in cm.) and calculated growth in percentages in 1935 of 'would-be flowering' and 'would-be non-flowering' shoots of various flushes

Name of flush	No. of shoots under observation in 1935	Extension growth both actual and calculated in 1935						No. of shoots 1936 (a) Flowering (b) Non-flowering		Actual or calculated growth
		April	May	June	July	August	Sept- ember			
April	200	12.3 %34.5	22.2 62.4	32.4 91.0	33.9 95.2	35.5 99.7	35.6 100.0	}	(a) 156	Actual Calculated
		11.4 %32.7	19.7 56.6	28.6 82.2	30.2 86.8	31.8 91.4	34.8 100.0			
May	100		9.7 %58.1	14.9 89.2	16.4 98.2	16.6 99.4	16.7 100.0	}	(a) 83	Actual Calculated
			9.0 %52.0	12.4 72.9	13.5 79.4	13.5 79.4	17.0 100.0			
June	100		..	10.6 %50.5	16.8 80.0	20.7 98.5	21.0 100.0	}	(a) 90	Actual Calculated
				9.3 %37.9	15.4 62.8	17.3 70.6	24.5 100.0			
July	10				7.5 %67.5	9.7 87.4	11.1 100.0	}	(a) 7	Actual Calculated
										

August	10			7.2 %61.0	7.2 61.0	11.8 100.0	(b) 3	Actual Calculated
	10				15.5 %100.0	15.5 100.0	(a) 5	Actual Calculated
	10				8.7 %55.4	15.7 100.0	(b) 5	Actual Calculated

TABLE XII

Mean total extension growth (in cm.) and calculated growth in percentages in 1935 of 'would-be flowering' and 'would-be non-flowering' shoots deblossomed in 1935

Total number of shoots deblossomed in 1935	No. of shoots flowering in 1936	Extension growth in 1935				Actual or calculated growth
		June 28	July 28	August 28	September 29	
27	Flowering	20	11.8 %60.5	17.7 90.8	19.0 97.4	19.5 100.0
	Non-flowering	7	1.7 %5.1	16.7 49.7	18.6 55.4	33.6 100.0

TABLE XIII

Growth performance and flowering records from 1935 to 1938 of shoots of various flushes selected in 1935

Name of flush	No. of shoots selected and growing in 1935	No. of shoots in 1936 (a) flowering (b) non-flowering	No. of shoots in 1936 (c) growing (d) non-growing	No. of shoots in 1937 (a) flowering (b) non-flowering	No. of shoots growing in 1937	No. of growths produced on shoots in col. 6	No. of shoots flowering in 1938 out of the shoots in column 7	Remarks
April	200	(a) 156 (b) 44	(c) 49 (d) 107 (c) 35 (d) 9	(a) 3 (b) 46 (a) 6 (b) 29	(a) — (b) 36 *(e) 46 (a) — (b) 21 (e) 4	107	125	*(e) in col. 6 shows the No. of shoots growing out of shoots in col. 4 which did not grow in 1936
May	100	(a) 83 (b) 17	(c) 4 (d) 79 (c) 1 (d) 16	(a) — (b) 4 (a) — (b) 1	(a) — (b) 3 (e) 9 (a) — (b) 1 (e) 2	15	10	Most of the shoots were in shade and did not grow probably due to this reason.
June	100	(a) 90 (b) 10	(c) 16 (d) 74 (c) 9 (d) 1	(a) 1 (b) 15 (a) 1 (b) 8	(a) — (b) 4 (e) 16 (a) — (b) 4 (e) —	24	15	

July	10	(a) 7	(c) —	(a) — (b) —	(a) — (b) — (c) 2 (d) 1 (e) 1	4	5	4
August	10	(a) 5	(c) —	(a) — (b) —	(a) — (b) — (c) 1 (d) 2 (e) 1	3	5	3

TABLE XV

Data of Table XIII regarding number of flowering and growing shoots represented on percentage basis

Name of flush	Percentage of growing shoots selected in 1935	Percentage of shoots flowering in 1936	Percentage of shoots growing in 1936	Percentage of flowering shoots in 1937	Percentage of growing shoots in 1937	Percentage of flowering shoots in 1938	Remarks
April	100.0	78.0	42.0	4.5	93.0	62.5	
May	100.0	83.0	5.0	..	21.0	10.0	
June	100.0	90.0	25.0	2.0	46.0	15.0	
July	100.0	70.0	30.0	20.0	50.0	40.0	
August	100.0	50.0	30.0	10.0	50.0	30.0	
Total	500.0	371.0	132.0	36.5	260.0	157.5	
Mean	100.0	74.2	26.4	7.3	52.0	31.5	

TABLE XVI

Growth performance and flowering records from 1935 to 1938 of shoots deblossomed in the spring of 1935

No. of shoots deblossomed in 1935	No. of shoots growing in 1935	No. of shoots (a) flowering (b) non-flowering in 1936	No. of shoots growing in 1936	No. of growths on shoots in the previous column	No. of shoots flowering in 1937	No. of shoots growing in 1937	No. of growths on the shoots in the previous column	No. of shoots flowering in 1938
27	27	(a) 20 (b) 7	.. 6	.. 14	.. 2	7 } 2 }	19	7

TABLE XVII

The data of Table XVI is represented on percentage basis on the original number of shoots

Percentage of shoots deblossomed in 1935	Percentage of shoots growing in 1935	Percentage of shoots flowering in 1936	Percentage of shoots growing in 1936	Percentage of shoots flowering in 1937	Percentage of shoots growing in 1937	Percentage of shoots flowering in 1938
100.0	100.0	74.1	51.8	7.8	70.4	26.0

TABLE XVIII

Mean total extension growth (in cm.) and calculated growth in percentages in 1937 of 'would-be flowering' and 'would-be non-flowering' shoots of various flushes

Name of flush		Number of shoots under observations in 1938	Mean shoot growth in cm. during 1937												Actual or calculated growth
			April		May		June		July		August		September		
15	30	15	30	15	30	15	30	15	30	15	30	15	30		
April	Flowering	33	7.3 %26.6	7.5 27.3	7.7 28.0	13.3 43.4	17.6 64.0	21.3 77.5	23.7 86.2	24.6 89.5	26.2 95.3	27.5 100.0	27.5 100.0	Actual Calculated	
	Non-flowering	57	5.3 %31.9	5.5 33.1	5.6 33.7	7.2 43.4	9.6 57.8	10.2 61.4	11.3 68.8	11.8 71.0	12.7 76.5	14.9 89.7	15.8 95.1	Actual Calculated	
May	Flowering	23	...	...	11.9 %43.8	13.6 55.7	18.9 77.5	21.8 88.5	23.1 94.6	23.5 96.4	23.5 96.4	24.4 100.0	24.4 100.0	Actual Calculated	
	Non-flowering	67	...	...	8.8 %41.3	9.7 45.5	13.1 61.5	14.6 68.5	16.1 75.5	16.6 77.9	16.6 77.9	19.2 90.1	20.7 97.2	Actual Calculated	
June	Flowering	19	...	...	...	...	9.1 %59.5	9.9 64.7	11.2 73.2	11.8 77.1	15.0 98.0	15.3 100.0	15.3 100.0	Actual Calculated	
	Non-flowering	77	...	...	...	...	8.5 %47.2	10.1 56.1	11.5 63.8	11.5 63.8	12.6 70.0	16.5 91.7	18.0 100.0	Actual Calculated	
July	Flowering	11	...	...	...	...	...	...	10.6 %54.4	10.6 54.4	19.5 100.0	19.5 100.0	19.5 100.0	Actual Calculated	
	Non-flowering	89	...	...	...	...	...	...	7.0 %61.9	7.0 61.9	7.6 67.2	10.4 92.0	11.2 99.1	Actual Calculated	
August	Flowering	7	...	...	...	...	...	...	...	...	11.2 %58.9	19.0 100.0	19.0 100.0	Actual Calculated	
	Non-flowering	93	...	...	...	...	...	...	...	...	9.9 %71.2	13.8 99.2	13.9 100.0	Actual Calculated	

NOTES

Notice No. 3 of 1939

THE following Plant quarantine regulations and import restrictions have been received in the Imperial Council of Agricultural Research. Those interested are advised to apply to the Secretary, Imperial Council of Agricultural Research, New Delhi, for loan.

I. LIST OF UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, SERVICE AND REGULATORY ANNOUNCEMENTS

1. *Consolidated Service and Regulatory announcements, January-March 1939*

2. *Quarantine and other official announcements—*

- (i) Japanese Beetle Quarantine (No. 48)—Revision of regulations.
- (ii) Pink Bollworm Quarantine (No. 52)—Revision of quarantine and regulations.

3. *Summaries of plant quarantine import restrictions—*

- (i) *Union of South Africa*.—Restrictions on the importation of hay and straw as packing for merchandise.
- (ii) *Eire (Irish Free State)*.—Chrysanthemum Midge Order amended—importation of chrysanthemum plants prohibited.
- (iii) *British Colony of Malta*.—Potatoes may be imported from Alexandria, Egypt.
- (iv) *Iran (Persia)*.—Disinfection certificate required for flower bulbs and ornamentals.
- (v) *Commonwealth of Australia*.—Restrictions on the importation of vegetables—amendment of regulation 21 of the Regulations effective September 19, 1935.
- (vi) *Commonwealth of Australia*.—Stone fruit trees from United States—Each State regarded as a country.
- (vii) *Colony of St. Lucia (British West Indies)*.—Importation of banana plants prohibited.
- (viii) *Mandated Australian Territory of New Guinea*.—Digest of plant quarantine import restrictions.
- (ix) *Republic of Finland*.—Precautions against foot-and-mouth disease.

(x) *British Colony and Protectorate of Sierra Leone*.—Revision of the digest of the plant quarantine import restrictions.

4. *List of intercepted plant pests, 1937*

II. OTHER ANNOUNCEMENTS

1. *Nyasaland Protectorate*—

(i) Proclamation No. 4 of 1939—import restrictions of certain plants, plant portions and plant products grown or produced in the territory administered by Companhia de Mozambique.

(ii) Proclamation No. 8 of 1939—import restrictions of certain plants or portions of plants from certain districts in the Cape Province of the Union of South Africa.

2. *Colony of St. Lucia*.—Proclamation—prohibition of importation of oil sands from Trinidad.

NOTIFICATION No. F. 7-6/39, DATED THE 15TH JUNE 1939, ISSUED BY THE GOVERNMENT OF INDIA, IN THE DEPARTMENT OF EDUCATION, HEALTH AND LANDS

THE following Order issued by the Ministry of Agriculture and Fisheries, London, called 'The Importation of Plants Order of 1939', is published for general information :—

STATUTORY RULES AND ORDERS

1939, No. 532

DESTRUCTIVE INSECT AND PEST, ENGLAND

THE IMPORTATION OF PLANTS ORDER OF 1939, DATED MAY 16, 1939 (D.I.P.-605)

The Minister of Agriculture and Fisheries by virtue and in exercise of the powers vested in him under the Destructive Insects and Pests Acts, 1877 to 1927^(a), and of every other power enabling him in this behalf, orders as follows :—

Definitions

1. In this Order, unless the context otherwise requires :—

'Importer' includes any person who, whether as owner, consignor or consignee, agent or broker, is in possession of or in anywise entitled to the custody or control of the article.

'Inspector' means an Inspector or other authorised officer of the Ministry of Agriculture and Fisheries.

(a) 40 & 41 Vict. c. 68, 7 Edw. 7. c. 4 and 17 & 18 Geo. 5. c. 32.

‘Minister’ means the Minister of Agriculture and Fisheries.

‘Plant’ includes tree and shrub, and the fruit, seeds, tubers, bulbs, corms, rhizomes, roots, layers, cuttings and other parts of a plant.

‘Raw vegetables’ includes raw tomatoes, raw aubergines, and raw salads, but does not include mushrooms or cucumbers.

‘Unhealthy’ means affected, with any insect, fungus, bacteria, or other vegetable or animal organisms or any agent causative of a transmissible crop disease.

Application of Order

2. Nothing in this Order shall be deemed to prohibit or restrict the landing or transshipment in England or Wales of any plant grown in Scotland, Northern Ireland, Eire, the Isle of Man or the Channel Islands.

Prohibition against landing and restriction on transshipment in England or Wales of certain potatoes

3. (1) The landing in England or Wales of any potatoes grown in the undermentioned countries is hereby prohibited :—

the United States of America, the Dominion of Canada and European France.

(2) The transshipment in England or Wales of any of the potatoes specified in paragraph (1) of this Article is prohibited except under and in accordance with the conditions of a licence issued by the Minister or by an Inspector.

(3) In this Article ‘potatoes’ includes potato haulms, leaves and stalks.

Prohibition of importation of plants of sugar beet and mangold and of chrysanthemum plants

4. (1) For the prevention of the introduction of virus diseases of sugar beet and mangold the landing in England or Wales of any plant of sugar beet or mangold of the species *Beta vulgaris* Linn. (except the seeds thereof) is hereby prohibited except under and in accordance with the conditions of a licence issued by the Minister or by an Inspector.

(2) For the prevention of the introduction of the Chrysanthemum Midge (*Diarthronomyia hypogaea* F. Löw.) the landing in England or Wales of any chrysanthemum plant (except the seeds thereof) is hereby prohibited except under and in accordance with the conditions of a licence issued by the Minister or by an Inspector.

Restrictions on landing in England or Wales of certain plants and potatoes

5. (1) The landing in England or Wales of any of the plants mentioned in the First Schedule to this Order and of potatoes is hereby prohibited, unless each consignment is accompanied by two copies of a certificate of a duly authorised Official of the Phytopathological Service of the country in which the plants or potatoes were grown in the form prescribed in the Second Schedule to this Order. The inspection referred to in the certificate shall be carried out not more than fourteen days prior to the date of shipment. The original of the certificate shall be forwarded by post by the exporter to the Horticulture Branch of the Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S. W. 1, before the plants or potatoes are dispatched. Except in the case of consignments imported through the post, a copy of the prescribed certificate shall be delivered to the proper Officer of Customs and Excise at the same time as and together with the entry relating to the consignment. In the case of consignments imported through the post, a copy of the prescribed certificate shall be affixed to each package.

(2) In the case of any of the plants mentioned in the First Schedule to this Order and grown in the United States of America the certificate required by paragraph (1) of this Article shall be the certificate of an Official duly authorised by the United States Department of Agriculture.

(3) The certificate prescribed in this Article shall, except in the case of a consignment consisting wholly of potatoes, include a statement to the effect that the consignment does not contain any plant of sugar beet or mangold or any chrysanthemum plant, or any plant of the genus *Ulmus* or of the undermentioned genera of the order Pinaceae, *viz.*, *Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Thuja*, and *Tsuga*, except the seeds thereof.

(4) In the case of any of the plants mentioned in the First Schedule to this Order and grown in European France the certificate required by paragraph (1) of this Article shall include a certificate of an Officer of the French Services d'Inspection Phytopathologique which shall be in the Form A or the Form B set out in the Third Schedule to this Order.

(5) In the case of any of the plants mentioned in the First Schedule to this Order and of potatoes grown in Belgium, Germany, Luxemburg, the Netherlands, or Switzerland the certificate required by paragraph (1) of this Article shall include a certificate of a duly authorised Official of the Belgian, German, Luxemburg, Dutch or Swiss Phytopathological Service, as the case may be, which shall be, where the certificate relates to a plant, in the Form A or the Form B set out in the Third Schedule to this Order (as the circumstances may require), and where the certificate relates to potatoes, in the said Form A.

(6) The reference in Article 3 of the importation of elm trees and conifers (Prohibition) Order of 1933 ^(a) to the certificates prescribed in Article 4 of the Importation of Plants Order of 1933, shall be read and have

(a) S. R. & O. 1933 (No. 1011), p. 748

effect as a reference to the certificate prescribed in paragraph (1) of this Article.

(7) Paragraphs (4) and (5) of this Article shall not apply to flower bulbs, corms, tubers or rhizomes.

(8) Nothing contained in this Article shall be deemed to permit—

- (i) the landing or transshipment in England or Wales of any potatoes of which the landing or transshipment is prohibited or restricted under Article 3 hereof ;
- (ii) the landing in England or Wales of any plant of sugar beet or mangold of the species *Beta vulgaris* Linn. or of any chrysanthemum plant of which the landing is prohibited or restricted under Article 4 hereof.

Restrictions on the landing in England or Wales of raw vegetables

6. (1) The landing in England or Wales between the twenty-first day of April and the thirtieth day of September in any year of any raw vegetables grown in European France or Switzerland is hereby prohibited unless each consignment is accompanied by a certificate of an Officer of the French Services d'Inspection Phytopathologique or of as duly authorised official of the Swiss Phytopathological Service (as the case may be) in the Form A or the Form B set out in the Third Schedule to this Order. Provided that this restriction shall not apply before the twenty-second day of May in any year to any consignment accompanied by a certificate of a duly authorised Official of the French Services d'Inspection Phytopathologique in the form set out in the Fourth Schedule to this Order.

(2) The landing in England or Wales between the first day of June and the thirtieth day of September in any year of any raw vegetables grown in Belgium, Germany, Luxemburg, or the Netherlands is hereby prohibited unless each consignment is accompanied by a certificate of a duly authorised Official of the Belgian, German, Luxemburg or Dutch Phytopathological Service (as the case may be) in the Form A or the Form B set out in the Third Schedule to this Order.

(3) The landing in England or Wales between the twenty-first day of April and the thirtieth day of September in any year of any raw vegetables grown in any country other than Belgium, European France, Germany, Luxemburg, the Netherlands or Switzerland is hereby prohibited unless each consignment is accompanied by a certificate of origin visé by a competent authority in the country of origin stating the country and place where the raw vegetables were grown.

(4) The certificates prescribed in this Article shall be delivered to the proper Officer of Customs and Excise at the same time as and together with the entry relating to the consignment,

(5) Nothing contained in this Article shall be deemed to permit the landing or transshipment in England or Wales of any potatoes of which the landing or transshipment is prohibited or restricted under Article 3 hereof.

Restrictions on the landing in England or Wales of certain raw apples

7. (1) The landing in England or Wales between the twenty-first day of April and the thirtieth day of September in any year of any cider apples grown in European France or Switzerland is hereby prohibited unless each consignment is accompanied by a certificate of an Officer of the French Services d'Inspection Phytopathologique or of a duly authorised Official of the Swiss Phytopathological Service in the Form A or the Form B set out in the Third Schedule to this order.

(2) The landing in England or Wales between the twenty-first day of April and the thirtieth day of September in any year of any cider apples grown in Belgium, Germany, Luxemburg or the Netherlands is hereby prohibited unless in the case of a consignment landed between the twenty-first day of April and the thirty-first day of May in any year each consignment is accompanied by a certificate of origin visé by a competent authority in the country of origin stating the country and place where the cider apples were grown; and in the case of a consignment landed between the first day of June and the thirtieth day of September in any year each consignment is accompanied by a certificate of a duly authorised Official of the Belgian, German, Luxemburg or Dutch Phytopathological Service (as the case may be) in the Form A or the Form B set out in the Third Schedule to this Order.

(3) The landing in England or Wales between the twenty-first day of April and the thirtieth day of September in any year of any cider apples grown in any European country other than Belgium, France, Germany, Luxemburg, the Netherlands or Switzerland, is hereby prohibited unless each consignment is accompanied by a certificate of origin visé by a competent authority in the country of origin stating the country and place where the cider apples were grown.

(4) The landing in England or Wales between the seventh day of July and the fifteenth day of November in any year of any raw apples grown in the United States of America is hereby prohibited unless each consignment is accompanied by a certificate of a duly authorised Inspector of the United States Department of Agriculture in the form set out in the Fifth Schedule to this Order.

(5) The certificates prescribed in this Article shall be delivered to the proper Officer of Customs and Excise at the same time as and together with the entry relating to the consignment.

Procedure where plants, potatoes, raw apples or raw vegetables are landed in contravention of this Order

8. (1) If plants, potatoes, raw apples or raw vegetables are landed in England or Wales in contravention of this Order, they shall forthwith be

destroyed or re-exported at the expense of the importer, unless they are otherwise disposed of in accordance with the terms of a licence issued by the Minister or by an Inspector.

(2) Such licence may provide for the examination of any such plants, potatoes, raw apples or raw vegetables, and after examination thereof, the Inspector shall give a certificate stating whether the plants, potatoes, raw apples or raw vegetables or any of them are unhealthy or not. Such plants, potatoes, raw apples or raw vegetables as are so certified to be unhealthy shall be dealt with in accordance with Article 10 hereof as the Minister or the Inspector may direct.

(3) The importer shall pay for the said certificate such fee as the Minister may determine not exceeding five pounds.

Powers of Inspector in respect of consignments of plants, potatoes, raw apples or raw vegetables

9. An Inspector, upon production if so required of his appointment or authority, may enter any premises and examine and take samples of any consignment or part of a consignment of plants, potatoes, raw apples or raw vegetables landed or suspected of having been landed in England or Wales, whether such consignment was accompanied by such certificates as are required by this Order or not. For the purpose of any examination under this Article, an Inspector may open, or require the importer to open, any package in the consignment.

Procedure in the case of unhealthy consignments of plants, potatoes, raw apples or raw vegetables

10. (1) If it appears to an Inspector at any time that any plants, potatoes, raw apples, or raw vegetables in any consignment or part of a consignment landed in England or Wales, are unhealthy, he may serve upon the importer a notice stating that such plants, potatoes, raw apples or raw vegetables have been found by him to be unhealthy, and requiring the importer, within such time as may be specified in the notice, to carry out such measures of disinfection or treatment as may be specified in the notice, or to destroy or re-export the whole or any part of the consignment.

(2) Any measure of disinfection or treatment required by a notice under this Article, shall be carried out by the importer upon whom the notice is served, under the supervision of an Inspector at a suitable place designated by the Inspector, and no part of the consignment shall be moved from the place designated without the written authority of the Minister or the Inspector.

(3) Charges for or in connection with the removal, storage, disinfection, treatment, destruction or re-exportation, required by any such notice, shall be paid by the importer on whom the notice is served.

(4) In this Article 'consignment' includes packing materials, cases and containers,

Licences

11. Notwithstanding any provisions of this Order, any plants, potatoes, raw apples, or raw vegetables may be landed in England or Wales under and in accordance with the conditions of a licence issued by the Minister or by an Inspector.

Service of notices, etc.

12. For the purpose of this Order, a notice shall be deemed to be served on any person if it is delivered to him personally or left for him at his last known place of abode or business or sent through the post in a letter addressed to him there ; and a notice purporting to be signed by an Inspector shall be *prima facie* evidence that it was signed by him.

Information to be given as to plants, potatoes, raw apples or raw vegetables landed in England or Wales

13. Every person who has or has had in his possession or under his charge any plants, potatoes, raw apples or raw vegetables landed in England or Wales, and every person who as auctioneer, salesman or otherwise, has sold or offered for sale any such plants, potatoes, raw apples or raw vegetables shall, if so required in writing by the Minister or an Inspector, give to the Minister or Inspector all such information as he possesses as to the persons who have or have had in their possession or under their charge such plants, potatoes, raw apples or raw vegetables provided that any information given under this Article shall not be available as evidence against the person giving same in any prosecution under this Order, except in respect of an alleged failure to comply with this Article.

Offences

14. Every person shall be liable on conviction to a penalty not exceeding ten pounds, or in respect of a second or subsequent offence to a penalty not exceeding fifty pounds who wilfully obstructs or impedes an Inspector in the exercise of his powers under this Order or who does any act in contravention of this Order or of the terms or conditions of any notice or licence served or issued thereunder, or fails to do any act which he is required to do by this Order or any such notice or licence.

This Article does not apply to the landing or attempted landing of anything in contravention of this Order, the penalty for which is provided by Section 1 of the Destructive Insects Act, 1877, as amended by the Destructive Insects and Pests Acts, 1907 and 1927.

Revocation of Orders

15. The Orders specified in the Sixth Schedule to this Order are hereby revoked.

Provided that the revocation shall not :—

- (i) affect the previous operation of such Orders or anything duly done or suffered under such Orders ; or

- (ii) affect any right, privilege, obligation or liability acquired, accrued or incurred under such Orders ; or
- (iii) affect any penalty incurred in respect of any offence committed against such Orders ; or
- (iv) affect any investigation, legal proceeding or remedy in respect of any such right, privilege, obligation, liability, or penalty as aforesaid ; and any such investigation, legal proceeding or remedy may be instituted, continued or enforced, and any such penalty may be imposed as if this Order had not been made.

Commencement

16. This Order shall come into operation on the first day of June nineteen hundred and thirty-nine.

Short title

17. This Order may be cited as the Importation of Plants Order of 1939.

In witness whereof the Official Seal of the Minister of Agriculture and Fisheries is hereunto affixed this sixteenth day of May nineteen hundred and thirty-nine.

(L. S.)

DONALD FERGUSON,

Secretary.

FIRST SCHEDULE

All living plants and parts thereof (except seeds) for planting.

SECOND SCHEDULE

This is to certify that (Strike out { the living plants
words not applicable). { a representative sample of the
living plants

included in the consignment of which particulars are given below, were/was thoroughly examined on the (date) by
..... (name)
a duly authorised Official of the
..... and found to be healthy,
no evidence of the presence of any insect, fungus or pest destructive to agricultural or horticultural crops having been found in them.

This additional statement must be given for all consignments except those consisting wholly of potatoes

It is further certified that the consignment does not contain any plant of the genus *Ulmus*, or of the genera of the Order Pinaceae, viz., *Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Thuja*, and *Tsuga*, or any plant of sugar beet or mangold (*Beta vulgaris* Linn.) or any chrysanthemum plant.

This additional certificate must be given for all potatoes :—

It is further certified that no case of the disease known as 'wart disease' or 'black scab' of potatoes (*Synchytrium endobioticum*) has occurred at any time on the farm or holding where the potatoes included in the consignment were grown, nor within two kilometers thereof.

(Signed).....

(Official Status).....

(Date).....

No. and description of packages.....

Distinguishing marks.....

Description of living plants or parts thereof.....

Stated to be grown at.....

Exported by.....

Name and address of consignee.....

Name of vessel.....

Date of shipment.....

Port of landing in England or Wales.....

THIRD SCHEDULE

FORM A

This is to certify that during the 12 months preceding the date of this certificate there has been no outbreak of the Colorado Beetle in.....
 (here insert name of country—
 either, Belgium, France, Germany, Luxemburg, the Netherlands or Switzerland) within a distance of 50 kilometres from the place where the living plants, potatoes, raw vegetables or cider apples (strike out words not applicable) included in the package or consignment described below were grown.

(Signed).....

(Official Status).....

(Date of issue of certificate).....

No. and description of packages.....

Distinguishing marks.....

Description of produce.....

.....

Stated to be grown at.....
 Exported by.....
 Name and address of consignee.....

 Name of vessel.....
 Date of shipment.....
 Port of landing in England or Wales.....

FORM B

In accordance with the authorisation contained in the General Licence No.....of the Ministry of Agriculture and Fisheries of England and Wales, this is to certify that the plants included in the package or consignment described below have been examined and have been found to be of the following species or kind.....

 and that the conditions prescribed in the above General Licence have been complied with.

(Signed).....

(Official Status).....

(Date).....

No. and description of packages.....

Distinguishing marks.....

Description of produce.....

Stated to be grown at.....

Exported by.....

Name and address of consignee.....

Name of vessel.....

Date of shipment.....

Port of landing in England or Wales.....

FOURTH SCHEDULE

This is to certify that the raw vegetables included in the package or consignment described below were grown in the Department of Nord or in the Department of Pas-de-Calais.

(Signed).....

(Official Status).....

(Date of issue of certificate).....

No. and description of packages.....

Distinguishing marks.....

Description of produce.....

 Stated to be grown at.....
 Exported by
 Name and address of consignee.....

 Name of vessel.....
 Date of shipment.....
 Port of landing in England or Wales.....

FIFTH SCHEDULE

This is to certify that the raw apples included in the package or consignment described below are of one of the following grades as recognised by the Department of Agriculture of the United States of America—

‘ U. S. Fancy ’

‘ U. S. (No. 1) ’

‘ Extra Fancy ’

‘ Fancy ’

(Signature).....

(Official Status).....

(Date).....

Description of consignment

Number and nature of packages.....
 Distinguishing marks.....
 Variety of apples.....
 Name and address of consignee.....

 Name of vessel.....
 Date of shipment.....
 Port of shipment.....

SIXTH SCHEDULE

The Importation of Plants Order of 1933.^(a)

The Importation of Plants (Amendment) Order of 1934.^(b)

The Importation of Plants (Amendment) Order of 1935.^(c)

The Importation of Plants (Amendment) Order of 1936.^(d)

The Importation of Plants (Amendment No. 2) Order of 1936.^(e)

The Importation of Plants (Amendment) Order of 1937.^(f)

The Importation of Plants (Amendment) Order of 1938.^(g)

C. D. DESHMUKH,

Joint Secretary to the Government of India.

**NOTIFICATION No. F. 7-6/39-A, DATED THE 29TH JUNE 1939 ISSUED
BY THE GOVERNMENT OF INDIA IN THE DEPARTMENT OF
EDUCATION, HEALTH AND LANDS**

AN Order similar to that published with this Department notification No. F. 7-6/39-A, dated the 15th June 1939, has been issued by the Department of Agriculture for Scotland.

C. D. DESHMUKH,

Joint Secretary.

**THE THIRD SESSION OF THE INDIAN STATISTICAL CONFERENCE,
MADRAS, 1940**

THE third session of the Indian Statistical Conference will be held in Madras in the first week of January 1940. It has been provisionally arranged that the Conference will be opened by His Excellency the Governor of Madras on the 3rd January 1940. On the invitation of the Mysore University arrangements have also been made for holding a special session in Mysore possibly on the 6th and 7th January.

In Madras the work of the Conference will be carried on in active co-operation with the Indian Science Congress as in previous years. Arrangements have been made for joint meetings with the Sections of Mathematics, Physics, Agriculture, and possibly the Section of Medicine and Public Health. There will also be a special session on Economic Statistics.

(a) S. R. & O. 1933 (No. 558), p. 735.

(b) S. R. & O. 1934 (No. 684) I, p. 458.

(c) S. R. & O. 1935 (No. 1225), p. 399.

(d) S. R. & O. 1936 (No. 313) I, p. 871.

(e) S. R. & O. 1936 (No. 1288) I, p. 874.

(f) S. R. & O. 1937 (No. 197), p. 659.

(g) S. R. & O. 1938 (No. 517) I, p. 1143.

The Hon'ble Mr. V. V. Giri, Minister for Labour and Industries, Government of Madras, has kindly agreed to preside over a special discussion on 'Labour Statistics'.

The Government of India, different Provincial Governments, many of the important Indian States and Universities in India have given their official recognition to the Conference and are expected in many cases to send official delegates.

The subscription for ordinary members of the Conference is Rs. 5 and for Associate and Student members Rs. 3 and Re. 1 respectively. Members of the Indian Statistical Institute will be entitled to become Ordinary members of the Conference without payment of any additional subscription. Ordinary members of the Conference will have the right to contribute papers, to attend all scientific and other meetings of the Conference and to receive, free of charge, all publications relating to the conference.

Papers and scientific contributions should be sent so as to reach the Honorary Secretary, Indian Statistical Institute, Statistical Laboratory, Calcutta, before the 15th December 1939.

Enquiries in regard to local arrangements and accommodation should be addressed to the Local Secretaries, Prof. P. J. Thomas, University of Madras, or Prof. K. B. Madhava, University of Mysore.

ALGAL-FLORA OF PADDY FIELD SOILS OF THE UNITED PROVINCES, I

WHILE commenting on my note 'On Algae Found in Soil Samples from an Alluvial Paddy Field of Faridpur, Bengal' published in *Science and Culture*, Vol. I, No. 5, p. 298, Mr. R. N. Singh has made some observations in his article 'An Investigation into the Algal-flora of Paddy Field Soils of the United Provinces, I' published in this Journal, Vol. IX, Part I, February 1939, pp. 55-77. As a reply to these criticisms, I might state that the object of the investigation was not to bring out those algae alone which can resist prolonged desiccation, but to identify all the algal types actually contained in the two samples, collected from the surface of a paddy field of Faridpur, as desired by the Imperial Council of Agricultural Research. Moreover, the material available did not offer the opportunities for studying the soil algae from various depths with regard to their economy in soil, etc.

The role of algae in fixing nitrogen in soil was not also the subject matter of my investigations. No special effort was, therefore, made to eliminate the bacteria, although as pure cultures as possible were made.

Although diatoms occur universally, none of them was found in any of my cultures. No other member of the green algae, except *Pleurococcus Naegeli* Chodat, made its appearance in the culture media used. The name for this species was given as it could be ascertained from available references at the time of sending out the note for publication. (J. C. Banerji).

REVIEW

The Soils of Central Africa, in particular of the Belgian Congo, Vol. I. The Lower Congo. By Professor J. BAËYENS. Published by The National Institute for Agronomical Studies of Belgian Congo, Brussels. Price Fr. 150. 1938

IN his preface to the book Sir John Russell refers to the rapid progress that has been made in agronomy as a result of the recognition of pedology as an independent branch of science and also congratulates Professor Baeyens on his successful researches. The book is comprehensive and the reviewer has no hesitation in stating that it is a valuable contribution to pedological studies. The object and scope of the investigations undertaken by the author will be evident from the following quotation :—

‘ The pedological study of the soils in the Belgian Congo may be considered either from a scientific or a practical point of view. The first must logically take precedence over the second. In order to obtain in a short time the practical results requested by State or private undertakings both studies were performed simultaneously. The first part of the book gives a general outlook on the pedological properties of the soils in the Lower Congo. The second part deals with their agricultural properties not directly on the matter of manure requirements but of their original value with their subsequent classification based on a general scale, including : very fertile, fertile, wanting, or bad soils. This is regarding the most important crop plants actually grown in the Lower Congo ’.

In order to organize a soil survey service according to modern pedological methods, research work was started in Central Africa in 1934-35. The results are discussed in the book under the following sections :—

The factors dealing with the fertility of the soil in the Lower Congo ; the importance of a study of profiles—the technique used in their study and description of some typical profiles ; the mechanical properties and the structure of the soils ; the water relationship—static and dynamic ; chemical and colloidal properties ; the organic matter and biological activity ; the climate and the pedological climate. These are followed by a section dealing with the classification and cartography of the soils. The next chapter deals with the genesis of the soils.

The above chapters form Part I of the book.

In the second part the principles on which a scale of pedological fertility can be based are dealt with. This is followed by discussion on the suitability of soils for the principal crops of the country, viz. cocoa, coffee, etc. These are followed by other sections dealing with the relative agricultural values based on pedological characteristics of the soils of the country.

The book contains 11 maps, 47 tables and a number of very interesting figures showing the topography, vegetation, typical profiles, etc. [J. N. M.].

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